Elementary Particles as Black Holes and Their Binding Energies

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According to the theories of gravity, we know that if an ordinary matter is compressed within its Schwarzschild radius, it will become black hole. A moving mass may become a black hole at a certain velocity, which can be called as the critical velocity. Elementary particles can be created from the collapsing of the ordinary matter into black hole at that critical velocity. Elementary particles behave as black holes under strong gravity. We find new modified de-Sitter solution of Einstein's field equations. The defect in mass of the ordinary matter when it is collapsed to elementary particles is present as the binding energy of the elementary particles.

1. Introduction

It is well known that short-range strong gravity acts at the level of elementary particles [1-7]. Unlike the universal gravitational constant G, the strong gravitational constant Γ depends on the type of objects. Tennakone [2] has treated the electron and the proton as black holes in the strong gravitational field and calculated the strong gravitational constant as $\Gamma = 3.9\times10^{28}\,\mathrm{m^3kg^{-1}s^{-2}}$. In [4], the author has found $\Gamma = 2.77\times10^{32}\,\mathrm{m^3kg^{-1}s^{-2}}$ by studying strong gravity, which plays an important role in the stability of elementary particles.

There is a possibility that the size of a moving body may reduce to the Schwarzschild radius and mass of that moving body may increase to such an extent that it becomes black hole. The value of $\mathrm{v}^2/\mathrm{c}^2$ so obtained can be used in the Schwarzschild solution of Einstein's field equations for centrally symmetric metric [1]. For, $\mathrm{v} = 0$, the Schwarzschild solution will be for a static body but for $\mathbf{v} \neq 0$, the Schwarzschild solution will be applicable for a dynamic body. The value of $\mathbf{v}^2$ so obtained can be used in de-Sitter space-time to obtain new results. It is already known that elementary particles behave as black holes under strong gravity [2, 3]. The expression for $\mathrm{v}^2/\mathrm{c}^2$ can be modified using the expression for the radius of an elementary particle under strong gravity in formulating the Schwarzschild solution of Einstein's field equations for centrally symmetric metric. For, $\mathrm{v} = 0$, the Schwarzschild solution will be for static elementary particles but for, $\mathrm{v} \neq 0$, the Schwarzschild solution will be applicable for dynamic elementary particles.

This paper is organized as follows. In Sec. 2, using the theory of relativity we consider the possibility that the size of a moving body may reduce to the Schwarzschild radius and its mass may increase to such extent that it becomes black hole. Elementary particles can be created from the collapsing of the ordinary matter into black hole. Treating elementary particles as black holes under strong gravity we find the modified de-Sitter solution of Einstein's field equations. In Sec. 3, we have calculated the expression for the binding energy of the elementary particles. Then, we present our conclusions in Sec. 4.

2. Elementary Particles as Black Holes

We already know that elementary particles behave as black holes under strong gravity whose radius (R_0) and mass (m_0) can be given by the formula:

$$R_0 = \frac{2\Gamma m_0}{c^2} \tag{1}$$

In Eqn. (1), for an electron putting $R_0 = R_e = 2.82\times10^{-15}\,m$ and $m_0 = m_e = 9.11\times10^{-31}\,kg$, we get the value of strong gravitational constant $\Gamma = 1.393\times10^{32}\,\mathrm{m^3kg^{-1}s^{-2}}$, which is close to the value obtained by the author [4] i.e., $\Gamma = 2.77\times10^{32}\,\mathrm{m^3kg^{-1}s^{-2}}$.

According to the special theory of relativity, there is length contraction and increment in mass when a massive body moves with velocity v. The relationship between moving length and rest length

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and moving mass and rest mass can be written as [8]:

$$L = L_0\sqrt{1-\frac{\mathbf{v}^2}{c^2}} \qquad (2)$$

$$M = \frac{M_0}{\sqrt{1-\frac{\mathbf{v}^2}{c^2}}} \qquad (3)$$

Where, L and L_0 are moving length and rest length of the body and M and M_0 are moving mass and rest mass of the body, respectively.

There is a possibility that the size of a moving body may reduce to the Schwarzschild radius and mass of the moving body may increase to such extent that it becomes black hole, which can be written as

$$L_0\sqrt{1-\frac{v^2}{c^2}} = \frac{2G_N M_0}{c^2\sqrt{1-\frac{v^2}{c^2}}} \qquad (4)$$

Solving Eqn. (4), we can calculate the velocity at which the moving body becomes black hole

$$L_0\left(1-\frac{v^2}{c^2}\right) = 1-\frac{2G_N M_0}{c^2} \;;$$

$$\frac{\mathbf{v}^2}{c^2} = 1-\frac{2G_N M_0}{c^2 L_0}\;; v = c\sqrt{1-\frac{2G_N M_0}{c^2 L_0}} \qquad (5)$$

The expression $\frac{\mathbf{v}^2}{c^2} = 1-\frac{2G_N M_0}{c^2 L_0}$ is used in the Schwarzschild solution of Einstein's field equations for centrally symmetric metric which is given by [1] as

$$ds^2 = c^2\left[1-\frac{2G_N M_0}{rc^2}\right](dt)^2 - \left[1-\frac{2G_N M_0}{rc^2}\right]^{-1} dr^2 - r^2(d\theta^2+\sin^2\theta d\phi^2) \qquad (6)$$

We can write, $\frac{\mathbf{v}^2}{c^2} = 1-\frac{2G_N M_0}{c^2 R}$, where R is the radius of the ordinary matter and can be used in the Schwarzschild solution of Einstein's field equations for centrally symmetric metric.

Let us assume that elementary particles are created from the collapsing of the ordinary matter into black hole at the critical velocity. These elementary particles behave as black holes under strong gravity. Here we have considered two cases: Case I as the special case and Case II as the general case.

Case I: We assume that there are n number of elementary particles, each having mass m_0 and radius R_0 and strong gravitational constant Γ.

$$R\sqrt{1-v^2/c^2} = n\,R_0 = \frac{n\,2\Gamma m_0}{c^2}$$

$$\Rightarrow \frac{\mathbf{v}^2}{c^2} = 1-\frac{4n^2\,\Gamma^2 m_0^2}{c^4 R^2}$$

The modified Schwarzschild solution of Einstein's field equations for centrally symmetric metric can be written as

$$ds^2 = c^2\left[1-\frac{4n^2\Gamma^2 m_0^2}{c^4 r^2}\right](dt)^2 - \left[1-\frac{4n^2\,\Gamma^2 m_0^2}{c^4 r^2}\right]^{-1} dr^2 - r^2(d\theta^2+\sin^2\theta d\phi^2) \qquad (7)$$

Case II: The ordinary matter moving with velocity v becomes black hole and collapses into an elementary particles. We assume that there are $n_1, n_2,...$ are the number of elementary particles created having the radii $R_{01}, R_{02},...$, masses $m_{01}, m_{02}...$ and the strong gravitational constants $\Gamma_1, \Gamma_2,...$. In this case,

$$R\sqrt{1-v^2/c^2} = \sqrt{n_1^2 R_{01}^2 + n_2^2 R_{02}^2 + n_3^2 R_{03}^2 + ...} \qquad (8)$$

$$\frac{\mathbf{v}^2}{c^2} = 1-\frac{1}{R^2}\left(n_1^2 R_{01}^2 + n_2^2 R_{02}^2 + n_3^2 R_{03}^2 + ...\right) \qquad (9)$$

Where,

$$n_1 R_{01} = \frac{2\Gamma_1 n_1 m_{01}}{c^2} \qquad (10)$$

Using Eqn. (10) in Eqn. (9) and then writing in the generalized form we will get

$$\frac{v^2}{c^2} = 1-\frac{4}{c^4 r^2}\sum_{i=1,2...}\Gamma_i^2 n_i^2 m_{0i}^2 \qquad (11)$$

Comparing Eqns. (5) and (11) we can write the modified Schwarzschild solution of Einstein's field equations for centrally symmetric metric for the elementary particles created from collapsing of the moving mass into black hole as:

$$ds^2 = c^2\left[1-\frac{4}{c^4r^2}\sum_i \Gamma_i^2 n_i^2 m_{0i}^2\right](dt)^2 - \left[1-\frac{4}{c^4r^2}\sum_i \Gamma_i^2 n_i^2 m_{0i}^2\right]^{-1} dr^2 - r^2(d\theta^2+\sin^2\theta d\phi^2) \quad (12)$$

3. Binding Energy of Elementary Particles

The static form of de-Sitter space-time can be given by [1]

$$ds^2 = c^2\left[1-\frac{1}{3}\Lambda r^2\right](dt)^2 - \left[1-\frac{1}{3}\Lambda r^2\right]^{-1} dr^2 - r^2(d\theta^2+\sin^2\theta d\phi^2) \quad (13)$$

Case I: When n number of elementary particles each having mass m_0 and radius R_0 are created. Binding energy of elementary particles can be calculated with the help of the Eqns. (7) and (13) in the following way:

$$\frac{1}{3}\Lambda r^2 = \frac{4n^2\Gamma^2 m_0^2}{c^4 r^2} \quad (14)$$

Solving Eqn. (14), we get

$$r = \left(\frac{2n\Gamma m_0}{c^2 H}\right)^{\frac{1}{2}} \quad (15)$$

From Eqns. (6) and (13), we will get

$$\frac{1}{3}\Lambda r^2 = \frac{2G_N M_0}{rc^2} \quad (16)$$

From Eqn. (16), we get $M_0 = \frac{c^2\Lambda r^3}{6G_N}$ and from Eqn. (15) $m_0 = \frac{c^2 H r^2}{2\Gamma}$.

Binding energy of the elementary particle can be calculated as

$$\text{B.E.} = (M_0 - nm_0)c^2 = \left(\frac{\Lambda r^3}{6G_N} - \frac{nHr^2}{2\Gamma}\right)c^4 \quad (17)$$

In Eqn. (17), n is the number of elementary particles created.

Putting the value of r from Eqn. (15) in Eqn. (17), we get the expression for binding energy of elementary particles as

$$\text{B.E.} = \left[\frac{\Lambda}{6G_N}\left(\frac{2\Gamma n m_0}{c^2 H}\right)^{\frac{3}{2}} - \frac{nm_0}{c^2}\right]c^4 \quad (18)$$

Case II: When $n_1, n_2, ...$ is the number of elementary particles created having radii $R_{01}, R_{02}, ...$ and masses $m_{01}, m_{02} ...$ Proceeding like our previous case, we can write the binding energy of elementary particles as

$$\textbf{B.E.} = [M_0 - (n_1 m_{01} + n_2 m_{02} + ...)]c^2 = \left(\frac{\Lambda r^3}{6G_N} - \frac{Hr^2}{2}\left(\frac{n_1}{\Gamma_1} + \frac{n_2}{\Gamma_2} + ...\right)\right)c^4 = \left[\frac{\Lambda}{6G_N}\left(2\frac{\Gamma_1 n_1 m_{01} + \Gamma_2 n_2 m_{02} + ...}{c^2 H}\right)^{\frac{3}{2}} - \frac{n_1 m_{01} + n_2 m_{02} + ...}{c^2}\right]c^4 \quad (19)$$

Eqn. (19) can also be written as

$$\text{B.E.} = \left[\frac{\Lambda}{6G_N}\left(\frac{2\sum_i \Gamma_i m_{0i}}{c^2 H}\right)^{\frac{3}{2}} - \frac{\sum_i n_i m_{0i}}{c^2}\right]c^4 \quad (20)$$

Using Eqn. (20), we can calculate the binding energy of elementary particles.

4. Conclusion

In our previous paper [9], considering the universe as a black hole, we showed that there are two possibilities for the expansion of the universe in future. The universe will either contract to a point or expand to infinity.

There is a possibility that the size of a moving body may reduce to the Schwarzschild radius and mass of the moving body may increase to such extent that it becomes black hole. Using the theory of relativity we show that ordinary matter behaves as black hole [10] at a certain velocity v due to gravity. Its Schwarzschild radius can be correlated with the radii of elementary particles, which behave as black holes under strong gravity. We get new different modified de-Sitter solution of Einstein's field equations. Finally, we have calculated the binding energy of elementary particles assuming that it has been formed through collapse of the ordinary matter into elementary particles, which can be considered as black hole under strong gravity within its radius. The defect in mass of the ordinary matter when it is collapsed to elementary particles is present as the binding energy of the elementary particles.

Acknowledgments

We thank the referee for suggesting valuable improvements of our manuscript.

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Received: 23 January, 2013
Accepted: 10 May, 2013