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Negative Gravity Force Created by Gravitational Collapse of the Star

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Abstract

General relativity theory predicts that the star of greater than 2.5 solar masses collapses into a black hole when it burns up all its nuclear fuel. But some scientists are skeptical about the existence of a black hole. The author studied the possible existence of faster-than-light phenomena for highly accelerated elementary particles. By applying his theorem to the collapsing star, it can be shown that negative gravity due to tachyons created inside the star prevents all the star's matter to be completely crushed into a singularity and it is considered that the collapsing stars become unstable by their negative gravity forces generated by created tachyons and they may be finally exploded.

Keywords: tachyon, gravitational collapse, negative gravity, black hole, superluminal speed, collapsing star.

1. Introduction

General relativity theory predicts that the star of greater than 2.5 solar masses collapses into a black hole when it burns up all its nuclear fuel. However some scientists are skeptical about the existence of a black hole and Prof.Jefimenko proposed the theory which denies gravitational collapse of the star by introducing a new gravitational field (Jefimenko, 1992).

Some researchers have proposed the theory that quantum effects prevent true black holes from forming dense entities called black stars (Barcelo et al., 2008; Visser et al., 2008; Skenderis et al., 2008).

Instead of their theory, the author also studied this problem from the standpoint of negative gravity due to the faster-than-light (FTL) particles, called tachyons by Feinberg, and he found that they prevent all the star's matter to be completely crushed into a singularity by its strong negative gravitational field.

2. Results

Probability of Elementary Particles Which Exceed Light Speed

According to the author's theorem (Musha, 1998), highly accelerated elementary particles have the possibility to be transformed into a tachyon by quantum tunneling effect (Musha, 2000), which is described by the Klein-Gordon wave equation shown as

$$i\hbar\frac{\partial\psi}{\partial t} = H\psi \quad , (1)$$

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where ψ is a wave function for the particle and $H = \sqrt{p^2c^2 + M^2c^4}$.

From the definition of proper acceleration given by $p = M\alpha t$, we have

$$\frac{\partial \psi}{\partial p} = -i\frac{c}{M\alpha\hbar}\sqrt{p^2 + M^2c^2}\psi, \quad (2)$$

From which, we have

$(v < c)$

$$\psi = C \cdot \exp\left[-i\frac{m_0 c^3}{2\alpha\hbar}\left(\frac{cv}{c^2 - v^2} + \log(m_0 c) + \frac{1}{2}\log\left(\frac{c+v}{c-v}\right)\right)\right], \quad (3)$$

and

$(v > c)$

$$\psi^* = C \cdot \exp\left[-\frac{m_* c^3}{2\alpha\hbar}\left(\frac{cv}{v^2 - c^2} - \log(m_* c) - \frac{1}{2}\log\left(\frac{v+c}{v-c}\right)\right)\right], \quad (4)$$

where m_0 is the mass of the elementary particle, m_* is an absolute value of the tachyon's rest mass, ψ_* is the wave function for the tachyon, v is the velocity of the particle, c is the light speed. From this equation, the probability of the elementary particle transformed into a tachyon can be shown as

$$T \approx \frac{|\psi_*|^2}{|\psi|^2} = \exp\left[-\frac{m_*\, c^3}{\alpha\,\hbar}\left(\frac{cv}{v^2 - c^2} - \log(m_* c) - \frac{1}{2}\log\left(\frac{v+c}{v-c}\right)\right)\right]. \quad (5)$$

From which the probability of tachyons created inside the collapsing star can be estimated.

Probability of Tachyons Created Inside the Star

Applying the uncertainty principle of momentum for the particle moving inside the quantum domain, we have

$$p_0 = \frac{m_0 v_0}{\sqrt{1 - v_0^{\,2}/c^2}} \approx \frac{\hbar}{d}, \quad (6)$$

where v_0 is the velocity of the particle and d is the size of the quantum domain in which the particle is moving.

From Eq.(6), the velocity of the moving particle is roughly estimated as

$$v_0 = c\left(1 + \frac{m_0^2 c^2 d^2}{\hbar^2}\right)^{-1/2} \approx c - \frac{c}{2}\left(\frac{m_0 cd}{\hbar}\right)^2, \quad (7)$$

if m_0 satisfies $m_0^2 c^2 d^2 << 1$. Then energy of the particle can be given by

$$E = \frac{m_0 c^2}{\sqrt{1 - v_0^2/c^2}} \approx \frac{c\hbar}{d}. \quad (8)$$

By the uncertainty principle, virtual particles, most of which are photons, can be emitted temporarily from particles moving inside the quantum domain.

According to Eq.(5), some of them have the possibility to be created as a tachyon.

Supposing that the virtual particle created as a tachyon satisfies the energy conservation shown as

$$E_* = \frac{m_* c^2}{\sqrt{v_*^2/c^2 - 1}} \approx \frac{c\hbar}{d} \text{ , (9)}$$

an absolute rest mass of the tachyon created becomes

$$m_* \approx \frac{\hbar}{cd}\sqrt{v_*^2/c^2 - 1} \text{ . (10)}$$

By the difference of the momentum, $\Delta p = p_* - p_0$ given by

$$\Delta p = \frac{m_* v_*}{\sqrt{v_*^2/c^2 - 1}} - \frac{\hbar}{d} \text{ , (11)}$$

where p_* is the momentum of the particle in a FTL state and p_0 is its original momentum.

From the uncertainty relation shown as $\Delta p \cdot d \approx \hbar$, FTL particles move at the velocity of almost twice the light speed. From which, the rest mass of the tachyon can be determined as

$$m_* \approx \frac{\sqrt{3}}{cd}\hbar \text{ . (12)}$$

By the definition of the proper acceleration of the particle as $\alpha = m_0^{-1}\Delta p / \Delta t$ (Jukov, 1961), the acceleration of the particle moving inside the quantum domain can be given by using the uncertainty principle as

$$\alpha = \frac{\hbar}{m_0 d \Delta t} \approx \frac{c\hbar}{m_0 d^2} \text{ . (13)}$$

Then the probability of tachyons created inside the star becomes

$$T(d) \approx \exp\left(-\frac{\sqrt{3}m_0 cd}{\hbar}\{\log(d/\hbar) + \gamma\}\right) \text{ , (14)}$$

where $\gamma = \frac{2}{3} - \log 3$.

Negative Gravity Force Generated by FTL Particles

From the Klein-Gordon equation, tachyon radiation can be described by

$$\left(\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2 - \left(\frac{m_* c}{\hbar}\right)^2\right)\psi = 0 \text{ , (15)}$$

Supposing that the Newtonian law of gravitation can be applied to tachyons which have an imaginary mass im_*, at a distance d apart, it is seen that the repulsive force is generated between them:

$$f = G\frac{(im_*)^2}{r^2} = -G\frac{{m_*}^2}{r^2} \text{ , (16)}$$

where G is a gravitational constant.

From Eq.(15), it has a static solution for the spherical coordinates system which we have

$$f = -G\frac{m_*^2}{r^2}\exp(-ir/r_0), \quad (17)$$

The differential equation of kinetic equilibrium between the inner pressure and gravitation for the condensed star was given by V.R. Emden (Sato, Ruffin, 1976) as

$$\frac{dP(r)}{dr} = -\frac{GM(r)}{r^2}\rho(r), \quad (18)$$

where $P(r)$ is a pressure at the distance r from the center of the star and $M(r)$ is a total mass inside the radius r given by

$$M(r) = 4\pi\int_0^r \rho(r)r^2 dr. \quad (19)$$

By this equation, the pressure at the center of the star is roughly estimated as

$$P_c \approx \frac{GM\rho_c}{R} = \frac{4\pi G}{3}\rho_c^2 R^2, \quad (20)$$

where R is a radius of the star and ρ_c is its mass density.

Negative Pressure Generated by FTL Particles Which Prevents Forming Black Holes

The event horizon of the black holes is given by (Kaufmann, 1980)

$$r_g = \frac{2GM_0}{c^2}. \quad (21)$$

where M_0 is a mass of the star.

When elementary particles of the star are packed so tightly by its strong gravitational field, virtual particles created inside the star are highly accelerated as their moving ranges are decreased. Hence it is considered from Eq.(14) that virtual particles created inside the collapsing star have a possibility to appear as tachyons. If we let d is the mean separation distance of elementary particles inside the star, the density of particles is roughly estimated as $N = 1/d^3$. Then the mean mass density of tachyons becomes

$$\bar{\rho} = Nm_* T(d) = \frac{\sqrt{3}\hbar}{cd^4}T(d). \quad (22)$$

As the mass density of the star with the mass M_0 can be given by

$$\rho \approx M_o \Big/ \frac{4\pi}{3}R^3, \quad (23)$$

the condensed star which is composed of real and imaginary particles, the mean mass density ρ_c of the star can be given by $\rho_c = \rho + i\bar{\rho}$.

By substituting this formula and Eq.(22) into Eq.(20), the inner pressure P_c becomes

$$P_c \approx \frac{4\pi GR^2}{3}\left[\rho^2 - \frac{3\hbar^2}{c^2 d^8}T(d)^2\right]. \quad (24)$$

If we let m_0 be a mass of the nucleon inside the star, we obtain

$$d = \sqrt[3]{\frac{4\pi m_0}{3M_0}}R \text{ , } (25)$$

by using the relation $\rho \approx Nm_0$.

From which, the inner pressure which can support the star against its strong gravitational field becomes

$$P_c \approx \frac{3G}{4\pi}\frac{M_o^2}{R^4} - \frac{G\hbar^2}{(4\pi)^{5/3}}\left(\frac{3M_0}{m_0}\right)^{8/3}\frac{T^2}{c^2R^6}, \quad (26)$$

where T is given by

$$T \approx \exp\left[-\frac{\sqrt{3}cR}{\hbar}\left(\frac{4\pi\ m_0^4}{3M_o}\right)^{1/3}\left\{\frac{1}{3}\log\left(\frac{4\pi m_0 R^3}{3M_0\hbar^3}\right)+\gamma\right\}\right]. \quad (27)$$

From these equations, the probability of tachyons created inside the collapsing star can be calculated as shown in Figure 1 for the neutron star which mass is 2.5 times solar masses.

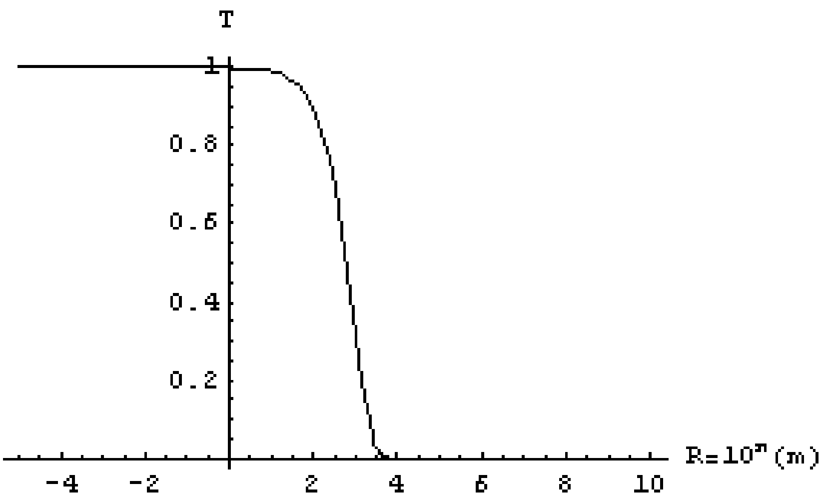

Fig. 1. Probability of a tachyon created inside the collapsing star which radius is R

Then the inner pressure at its center divided by mass energy density, $P_c/\rho c^2$, can be estimated from Eq.(26) as shown in Figure 2.

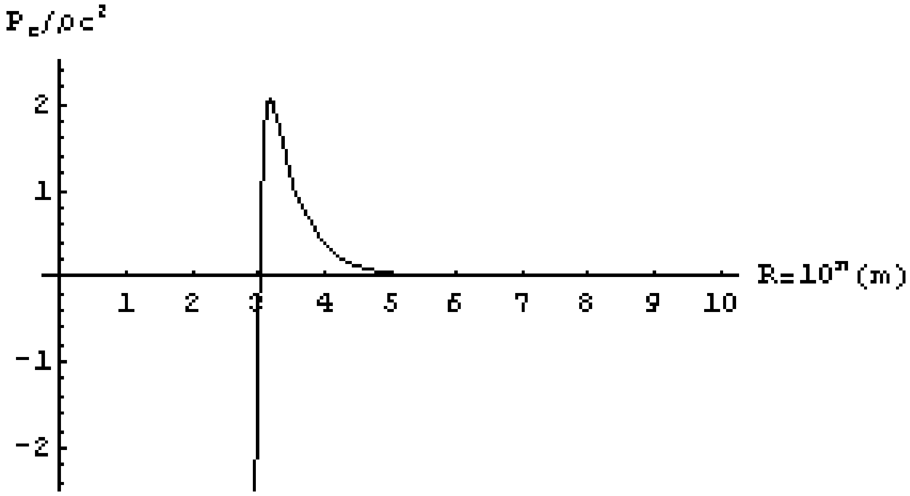

Fig. 2. Inner pressure divided by energy density for the collapsing star

From this calculation result, it is seen that there is a point at which the negative gravity force by tachyons cancels the gravitational field of the collapsing star. Thus the gravitational collapse is stopped when the radius of the star reaches

$$R_0 \approx \frac{3^{5/6}\hbar T_0}{c}\sqrt[3]{\frac{M_0}{4\pi m_0^4}}, (28)$$

where T_0 is the probability given by Eq.(27) when $P_c = 0$.

As the probability of the virtual particle created inside the star is less than unity, the radius of the star does not get smaller than

$$R_0 / r_g \approx \frac{3^{5/6}\hbar c}{2G\sqrt[3]{4\pi m_0^4 M_0^2}}, (29)$$

The calculation of r_g / R vs. M_0 for the star, which is composed of neutrons, is shown in Figure 3.

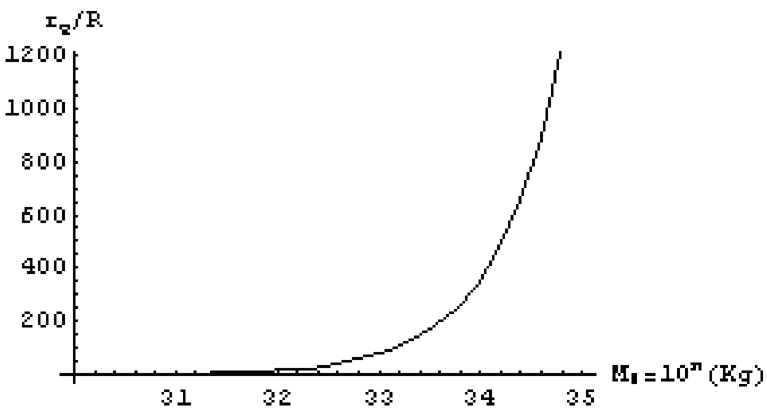

Fig. 3. r_g / R for the neutron star which mass is M_0

If strong gravitational field crushes nucleons down to more elementary particles like quarks, negative gravity by tachyons increases rapidly as shown in Figure 4 by the formula:

$$R_0 / r_g \approx \left(\frac{\sqrt{3} c M_0}{4\pi \hbar} d^4 \right)^{1/2}, (30)$$

which is calculated for the star which has 2.5 solar masses.

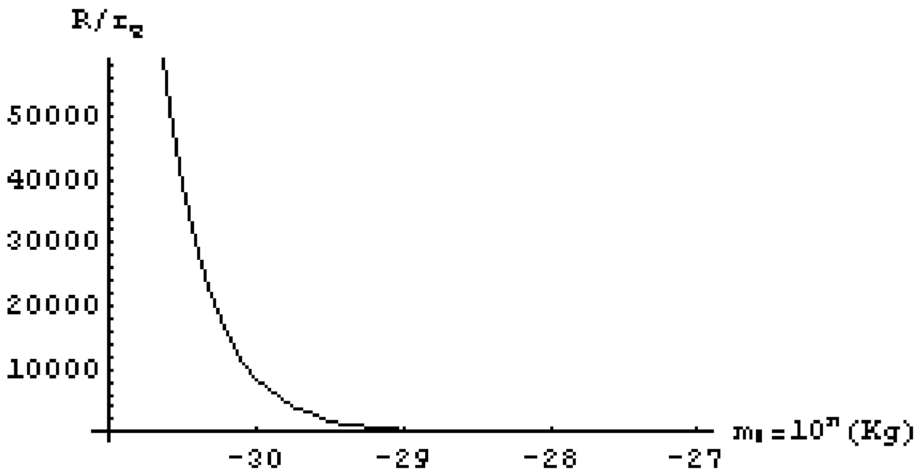

Fig. 4. R / r_g vs. the mass for the particle inside the star

From this calculation result, it is considered that the collapsing stars become unstable by their negative gravity forces generated by tachyons and they may be finally exploded.

In astronomical observation, apparently superluminal motion was seen in ejected flow of matter by the explosion of the stars, which can be observed as a jet moving at a some radio galaxies, quasars, and recently also in some galactic sources called microquasars. Bursts of energy moving out along the relativistic jets emitted from these objects can have a proper motion that appears greater than the speed of light as shown in Figure 5. All of these sources are thought to contain a black hole, responsible for the ejection of mass at high velocity, which can produce apparent superluminal motion (Bond, 2003).

This may be due to the tachyons created inside the collapsing stars where the jet emitted from them are composed of superluminal particles.

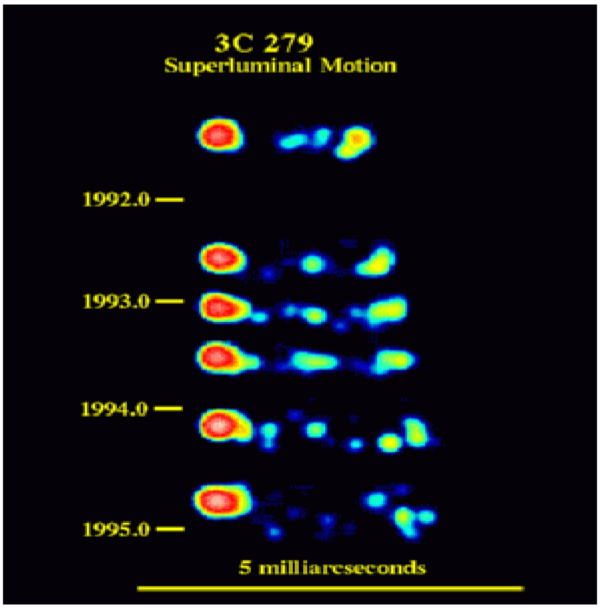

Fig. 5. Superluminal motion of the Quasar 3C 279

3. Conclusion

By the theoretical analysis, it is shown that the negative gravity force by tachyons created inside the star prevents all the star's matter to be completely crushed into a singularity. It is also shown that the black holes may be finally exploded when strong gravitational field crushes nucleons down to more elementary particles.

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