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Tachyon Field and Non-Existence of Dark Matter

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Abstract

From the observation data, there is a significant discrepancy between the observed rotation curve of a disc galaxy and a curve derived from the theory. The theory of dark matter is currently postulated to account for the variance. Contrary to this assumption, authors present a theory by using tachyon field in the intetrgalactic space to explain the variance of the rotation curve of a disc galaxy.

Keywords: tachyon, dark matter, rotation curve, disk galaxy, large-scale structure.

1. Introduction

The galaxy rotation problem is the discrepancy between observed galaxy rotation curves and the theoretical prediction, assuming a centrally dominated mass associated with the observed luminous material. When mass profiles of galaxies are calculated from the distribution of stars in spirals and mass-to-light ratios in the stellar disks, they do not match with the masses derived from the observed rotation curves and the law of gravity as shown in Figure 1 (Corbelli, Salucci, 2000; Bosma, 1978; Rubin et al., 1980). A solution to this conundrum is to hypothesize the existence of dark matter and to assume its distribution from the galaxy's center out to its halo (Hammond, 2008).

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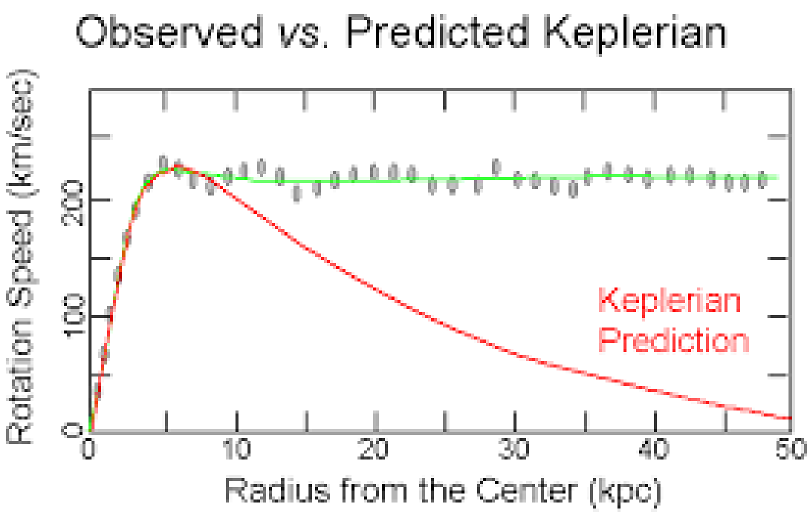

Fig. 1. Discrepancy of the observed rotation speed of the Galaxy from the theoretical calculation

Though dark matter is by far the most accepted explanation of the rotation problem, other proposals have been offered with varying degrees of success. Of the possible alternatives, the most notable is Modified Newtonian Dynamics (MOND), which involves modifying the laws of gravity (Bekenstein, 2004; Keller, Wadsley, 2017). There have been a number of attempts to solve the problem of galaxy rotation by modifying gravity without invoking dark matter. One of the most discussed is Modified Newtonian Dynamics (MOND), originally proposed by Mordehai Milgrom in 1983, which modifies the Newtonian force law at low accelerations to enhance the effective gravitational attraction. MOND has had a considerable amount of success in predicting the rotation curves of low-surface-brightness galaxies, matching the baryonic Tully–Fisher relation, and the velocity dispersions of the small satellite galaxies of the Local Group. MOND is not a relativistic theory, although relativistic theories which reduce to MOND have been proposed, such as tensor–vector–scalar gravity, scalar–tensor–vector gravity (STVG), and the f(R) theory of Capozziello and De Laurentis (Moffat, 2006). Instead of Dark matter and MOND, which is an alternative theory to predict the rotation curve of a disk gravity, authors attempt to explain the rotational problem from the stand point of tachyon field in the intergalactic space. It can also explain the large-scale strucyure of the Universe.

1. Tachyon field generated in the intergalctic space

The interaction of tachyons in the gravitational field ca be descrived as

$$S_{tachyon}[g,X]=\mu c\int\sqrt{g_{\alpha\beta}(X(\lambda))\frac{dX^{\alpha}}{d\lambda}\frac{dX^{\beta}}{d\lambda}}d\lambda\,, \qquad (1)$$

where μ is the proper mass of tachyon, c is the light speed, λ is an affine parameter and X is a 4 dimentional coordinate of the particle.

From which, the energy-momentum tensor can be given by

$$T^{\alpha\beta}(x)=\frac{2}{\sqrt{-g}}\frac{\delta}{\delta g_{\alpha\beta}(x)}S_{tachyon}[g,X]\,, \qquad (2)$$

where $[g_{\alpha\beta}]=[\eta_{\alpha\beta}]=\begin{bmatrix}-1 & 0\\ 0 & 1\end{bmatrix}$.

Then Eq.(2) can also given by (Hotta)

$$T^{\alpha\beta}(x^0,x^1)=\mu c\int\frac{dX^{\alpha}}{d\lambda}\frac{dX^{\beta}}{d\lambda}\delta(x^0-X^0(\lambda))\delta(x^1-X^1(\lambda))d\lambda\,, \qquad (3)$$

which satisfies the equation shown as

$$E^2-(Pc)^2=-\mu^2c^4\,. \qquad (4)$$

As the energy-momentum tensor of ordinary particles can be written as

$$T^{\alpha\beta}(x^0, x^1) = mc\int \frac{dX^\alpha}{d\tau}\frac{dX^\beta}{d\tau}\delta(x^0 - X^0(\tau))\delta(x^1 - X^1(\tau))d\tau \,. \qquad (5)$$

From which, if $\mu < 0$, the energy of tachyon becomes negative from Eq(3), and then replsive force is generated between tachyons and ordinary matters.

Musha and Hayman proposed that cosmic background radiation is due to the Cherenkov radiation from vertual tachyon pairs created ZPF energy field in the vacuum (Musha, Hayman, 2013).

Furthermore, Caligiuri recently proposed a model (Caligiuri, 2019) in which tachyons can be originated as the consequence of the coherent dynamics of quantum vacuum occurring in condensed matter. More precisely It has been shown (Caligiuri, 2016; Preparata, 1995) that, under suitable boundary conditions, the quantum vacuum fluctuations are able to couple so strong with a matter systems, through its proper resonances, to induce the system to “runaway”, through a “Superradiant Phase Transition” (SPT), from the a Perturbative Ground State, characterized by the quantum zero point oscillations of e.m. field and matter, towards a more stable (true) ground state, named the Coherent Ground State (CGS), in which both the e.m. field and matter system oscillate in phase with each other at a common frequency ω_{coh}.

The resulting coherent state is characterized by a collective common behavior of the quantized e.m and matter fields appearing as a macroscopic quantum object in which atoms and molecules lose its individuality to become part of a whole electromagnetic field + matter entangled system, similar, in many regards, to that characterizing a Bose-Einstein Condensate (BEC).

One of the most remarkable consequences of the coherent phase transition is the formation, inside the macroscopic quantum coherent e.m. + matter system, of the so-called “Coherence Domains” (CDs), namely the smallest spatial regions in which the coherent evolution of the e.m. + matter field takes place, resulting from the coupling amplification between Zero-Point matter and gauge fields due to the coherent interaction. This kind of interaction determines, inside each CD, the creation of a coherent electromagnetic field whose frequency ω_{coh} is lower than the frequency ω_0 of free (uncoherent and perturbative) electromagnetic field associated to zero-point quantum fluctuations. The condition $\omega_{coh} < \omega_0 = 2\pi/\varphi\lambda_0$ gives, when used in the Einstein equation for such type of photons (Caligiuri, 2019)

$$E^2 - p^2c^2 = \hbar^2\omega_{coh}^2 - \hbar^2\left(\frac{2\pi}{\lambda_0}\right)^2 = \hbar^2\omega_{coh}^2 - \hbar^2\omega_0^2 = -M^2 < 0\,, \qquad (6)$$

telling us, for example, the coherent e.m. field is “trapped” inside the CD. On the other hand, as shown by Caligiuri (Caligiuri, 2019), equation (6) can be also deduced from a Klein-Gordon like equation

$$\square\tilde{\Psi}(X_\mu) = -\xi^2\tilde{\Psi}(X_\mu)\,, \qquad (7)$$

where $\square = (1/c^2)\partial_T^2 + \partial_{X_1} + \partial_{X_2} + \partial_{X_3}$ and $\xi^2 = \mu^2c^2/\hbar^2$ where μ is the rest tachyon mass. This quantum field equation holds in a superluminal (tachyonic) manifold $\tilde{E}_4$ equipped with the “space-like” metric given by

$$dS^2 = G_{\mu\nu}dX^\mu dX^\nu \quad \mu,\nu = 1,2,3,4\,, \qquad (8)$$

where X^μ are the space and time coordinates defined in a tachyonic reference frame (TRF), $G_{\mu\nu}$ is the metric tensor defined by

$$[G_{\varpi\nu}] = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \qquad (9)$$

So that we always have, in the TRF, $dS^2 > 0$. In such a TRF, two events are then always separated by a space-like distance also defining a true space axis. As a very important consequence of this formulation (Caligiuri, 2019), the tachyon rest mass is real and experimentally accessible both in a TRF and in an ordinary reference frame (ORF) like the usual Lorentz ones. Then, according to this model (Caligiuri, 2019), spontaneous fluctuations of quantum vacuum are able to give rise, when the local density is sufficiently high, to the formation of coherent domains entrapping a coherent e.m. field composed by evanescent photons or tachyons.

The tachyonic Klein – Gordon equation (7) is, on the other hand, a truly quantum field equation in which the wave-function $\tilde{\Psi}$ plays, as usual, the role of an hermitian operator of the tachyonic field (of spin zero and mass μ that can be decomposed as

$$\tilde{\Psi} = \tilde{\Psi}_1 + i\tilde{\Psi}_2 , \qquad (10)$$

in which the real and complex components of the field, associated to its two degrees of freedom, represent the electric charge of a charged tachyon particle. This allows us to develop, as it will be discussed in a forthcoming paper, a quantum field theory of charged tachyons in which we can respectively define the creator and annihilation operators $\tilde{\Psi}^{\dagger}$ and $\tilde{\Psi}$, and also to consider a tachyons field as a true tachyon-antitachyon field.

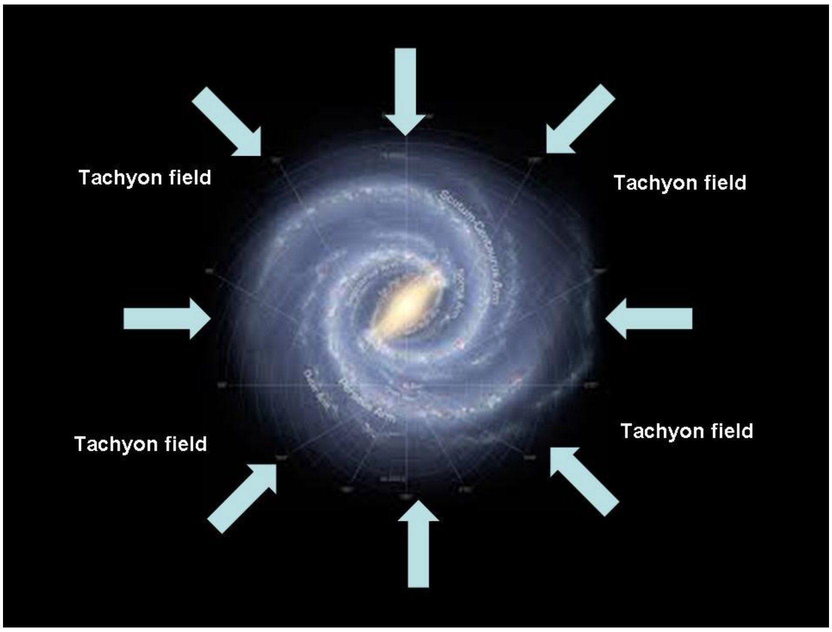

Fig. 2. Repulsive forces to the galaxy from tachyon field in the intergalactic space

If virtual tachyon pairs will radiate electromagnetic energy by Chrenkov effect, they become true tachyons and it is considered that they fill the intergalaxtic space of the Universe.

Thus tachyon field exserts repulsive force to the disk galaxy as shown in Figure 2.

If we introduce the parameter f, which is the repulsive force of tachyon field in the intergalactic space, the kinetic equation of stars can be given by

$$m\frac{v^2}{r} = G\frac{M(r)m}{r^2} + f . \qquad (11)$$

If we suppose $f \approx m\alpha$, where α is an acceleration of starts induced by the repulsive force of tachyon field, then we have

$$v \approx \sqrt{\frac{GM(r)}{r} + \alpha\ r}\ . \qquad (12)$$

The following figure shows the disk galaxy and its mass density.

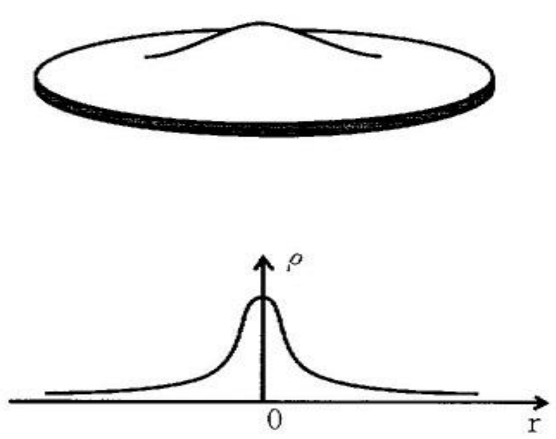

Fig. 3. Mass density of a disc galaxy

From mass density of the galaxy shown in Figure 3, we have the approximation shown as

$$M(r) = \int \rho dV \approx M(1 - \exp(-\beta\ r))\,, \qquad (13)$$

where β is an arbitrary constant.
Thus the rotation velocity of stars becomes

$$v \approx \sqrt{\frac{GM}{r}(1 - \exp(-\beta\ r)) + \alpha\ r}\ , \qquad (14)$$

If we let $\alpha = 0$, we obtain the velocity curve of a disc galaxy without the repulsive force of tachyon field as shown in Figure 4.

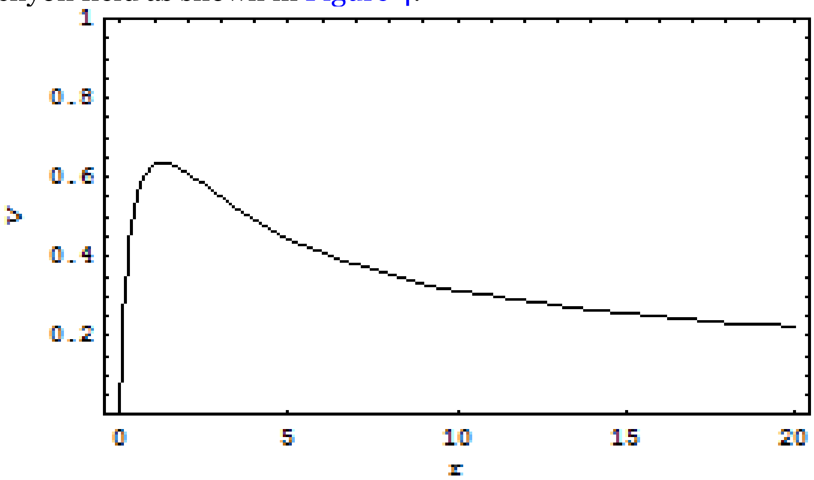

Fig. 4. Rotation curve of the galaxy without the repulsive force of tachyon field ($GM = 1, \beta = 1$)

In this figure, the horizontal line is for the distance from the center of the galaxy and the vertical line is for the rotational velocity of starts.

If we let $\alpha = 0.01$, which is the repulsive acceleration of tachyon field, we obtain the velocity curve as shown in Figure 5.

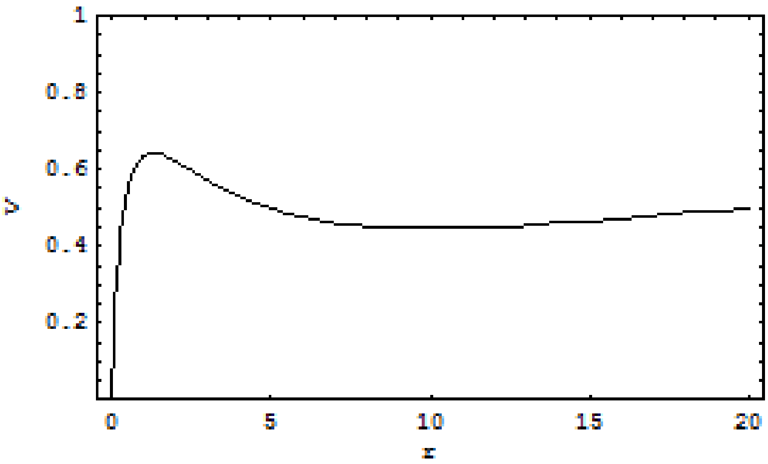

Fig. 5. Rotation curve of the galaxy considering the repulsive force of tachyon field ($GM = 1, \beta = 1$)

Figure 6 shows the observed data of rotational speed of galaxies.

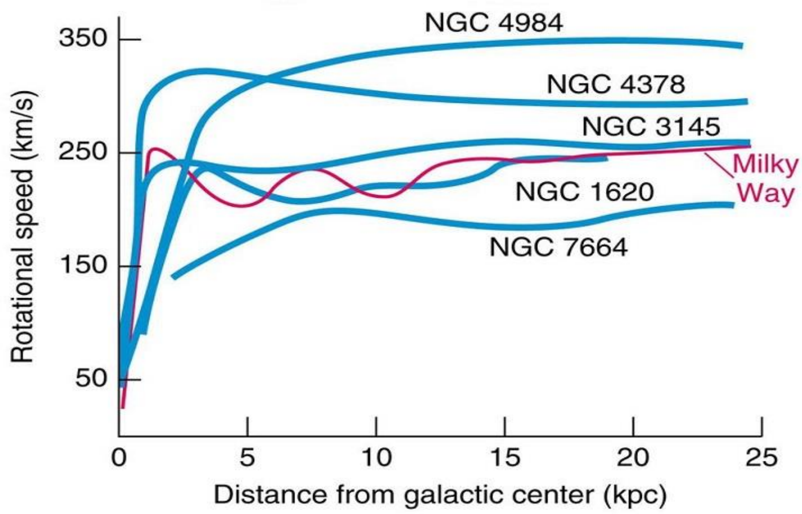

Fig. 6. Observed rotation curves of galaxies (Galaxy rotation speed)

Compared Figure 4 and Figure 5 with Figure 6, we can see that Figure 5 considering force by tachyon field coincides well with the observed data of the rotational speed of disc galaxies.

Dark matter has not yet been observed directly, it must barely interact with ordinary baryonic matter and radiation. The primary candidate for dark matter is some new kind of elementary particle that has not yet been discovered, in particular, weakly-interacting massive particles (WIMPs), or gravitationally-interacting massive particles (GIMPs). Many experiments to directly detect and study dark matter particles are being actively undertaken, but none has yet succeeded. Dark matter is classified as cold, warm, or hot according to its velocity (more precisely, its free streaming length). Current models favor a cold dark matter scenario, in which structures emerge by gradual accumulation of particles.

Hence many scientists think that dark matter is by far the most accepted explanation of the rotation problem, and no sign of the existence of dark matter is revealed by the observation.

By considering the tachyon field which repels ordinary matters, it is seen that the observation data of galaxies can be explained.

If we can accept the existence of repulsive tachyon field in the intergalactic space, the riddle of the rotation problem of galaxies can be solved.

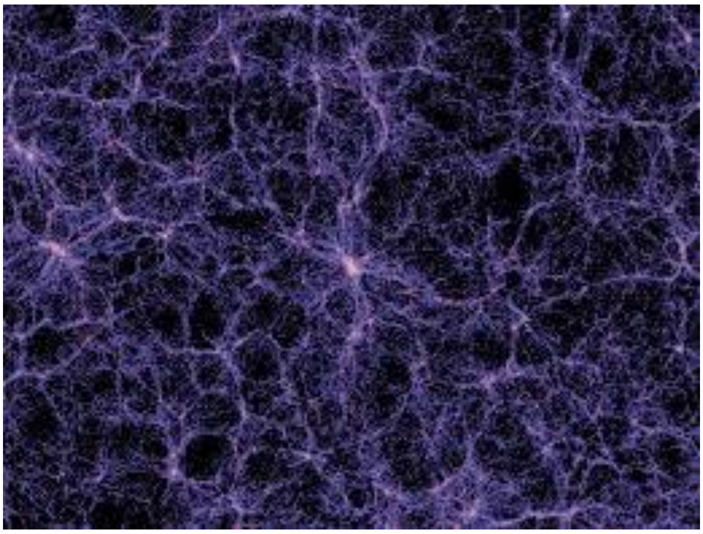

Fig. 7. Large-scale structure of the Universe

J.P. Petit attempted to explain the large scale of the Universe, as shown in Figure 7, introducing the anti-matter cloud surrounding galaxies (Petit, 1994), but tachyons repel each other and this can explain well the existence of void and the large-structure of the Universe without the anti-matter cloud.

This is like the water bubbles, which trap water on their surfaces as shown in Figure 8.

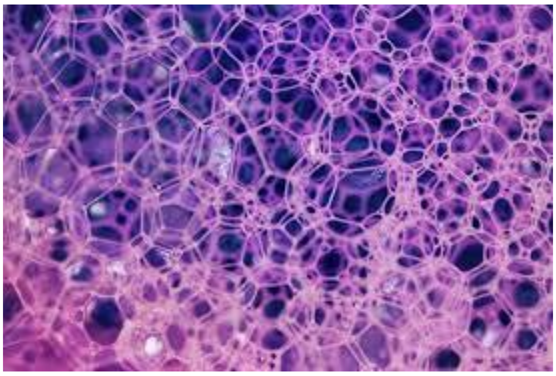

Fig. 8. Bubbles trap water on their surfaces, which is like the large-scale structure of the universe

Hence we can consider that galaxies are trapped by repulsive forces of the tachyon field like water bubbles which trap water on their surface.

Furthermore, the generation of tachyons in a space may assist the expansion of the Universe, and there is no need of dark energy.

3. Conclusion

Dark matter is a hypothetical form of matter that is thought to account for approximately 85 % of the matter in the universe, and about a quarter of its total energy density. The majority of dark matter is thought to be non-baryonic in nature, possibly being composed of some as-yet undiscovered subatomic particles. Its presence is implied in a variety of astrophysical observations, including gravitational effects that cannot be explained unless more matter is present than can be seen. For this reason, most experts think dark matter to be ubiquitous in the universe and to have had a strong influence on its structure and evolution

Instead of the presence of dark matter, we consider that intergalactic space is filled with tachyon field, and it can be seen that the rotation curve of a disk galaxy can be explained without dark matter. Furthermore, the repulsive tachyon field in the intergalactic space can explain large-scale structure of the Universe and also non-existence of dark energy.

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