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SHORT COMMUNICATION

Antimatter in Hidden Dimensions: A Possible Origin of Dark Energy

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ABSTRACT

This paper presents a possible origin of dark energy, which is believed to be the cause of accelerated expansion rate of the cosmos with the aid of superstring theory and the observed matter-antimatter asymmetry. It proposes a model in which the antimatter, and particularly antiquarks, occupies the Calabi-Yau manifold in six dimensions and thus attracts the quarks via 'gluons'. This phenomenon creates an illusionary vision. This paper also provides a conceivable explanation of the observed matter-antimatter asymmetry in the visible universe.

***Keywords*:** Dark energy, Anti-matter, Unobserved Dimensions, Accelerated Cosmic Expansion, Strong Nuclear force

1. INTRODUCTION

Spectral and photometric observations of 10 Type IA Supernovae, with redshift in the range $0.16 \leq z \leq 0.62$, combined with results from High-Z supernovae observations confirms

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that the deceleration parameter Q_0 of the universe is less than zero, with higher confidence levels (3.0σ and 4.0σ for two curve fitting methods) if vacuum energy density, $\Omega > 0$, compared to $\Omega < 0$ [1, 2]. Dynamical dark energy models have been favoured to explain the observations [3]. Moreover, the effect of dark energy is much more pronounced than gravitational force acting between massive galaxies. Although many models of dark energy have been suggested, none of these has been successful in explaining how this repulsive force becomes many orders of magnitude larger than gravitational force. Allowance for weak C and T violations and baryon-antibaryon asymmetry lead to matter-antimatter asymmetry in the observable universe [4]. This paper aims to propose a possible model of dark energy, which satisfies the magnitude criterion and also deciphers the case of matter-antimatter asymmetry.

2. PROPOSED MODEL

2. 1. Explanation of Matter-Antimatter Asymmetry

The six extra spatial dimensions in string theory are curled up in into a minuscule space, called the Calabi-Yau space, which are present at every point in space [5]. However the extortionate curvature and miniature size of these dimensions restrain us from realizing their significances as distinct dimensions. At least some of the extra spatial dimensions can be probed at length scales as large as 1 mm [6]. This is much larger compared to the typical size of a quark or an antiquark (10-18 meters maximum) [7]. As a result, the Calabi-Yau Space is large enough to accommodate a plethora of anti-matter. The observed matter-antimatter asymmetry could be due to the fact that antimatter is present in large quantities in these unobservable dimensions. As the explanations and calculations below suggest, it is not impossible that theantimatter in these dimensions is the much coveted dark energy. One assumption in this model is that anti-quarks can exist freely in the extra-spatial dimensions.

2. 2. Expansion of the Universe in terms of antimatter in the Calabi-Yau Space

The six unobservable dimensions exist are embedded in the fabric of four dimensional space-time. Thus, when any stars or galaxies approach the Calabi-Yau space very closely (of the order of magnitude of nuclear separation), strong nuclear force comes into play. According to the theory of quantum chromodynamics, the gauge boson ‘gluon’ carries a colour- anticolour charge and hence is able to mediate the residual strong interaction between the anti-quarks (in extra spatial dimensions) and quarks, confined within baryons of galaxies (via exchange of gluons). Over such distances, the strong interaction becomes significantly higher than gravitational force between distant galaxies within typical separation. As a result, the stars and galaxies are pulled towards these unobservable dimensions and since the dimensions exist everywhere in space, the effect is very pronounced. However, this does not mean that no net force to acts on the galaxies, as one may think. Figure 1, depicts the virtual representation of the proposed model.

Anti-matter is not likely to be perfectly symmetrically distributed in the Calabi-Yau space because it, too, is supposed to experience quantum fluctuations just after the Big Bang, just like the non-homogenous distribution of matter in space time (assuming that the universe is not observed on such a large scale that it obeys the Cosmological Principle) [8]. A galaxy will experience acceleration in the direction in which the net force acts on the galaxy, i.e. in the direction in which the density of anti-matter is highest. Whatever that direction is it is definitely towards the Calabi-Yau space. Human eyes are sensitive to detect motion only with respect to the three observable spatial dimensions. A movement towards any of the hidden dimensions in the Calabi-Yau space is interpreted as a movementaway from the observable dimensions and hence redshift is observed for distant galaxies[10].Since, free quarks cannot exist on their own, the possibility of annihilation is ruled out in the model since no free quark comes into contact with anti-quarks occupying the six extra spatial dimensions[11]. Confinement of quarks has been retained in this model in accordance with asymptotic freedom. Only the independent existence of anti-quarks has been assumed on the basis of violation CPT symmetry, thereby contravening asymptotic freedom [12, 18].

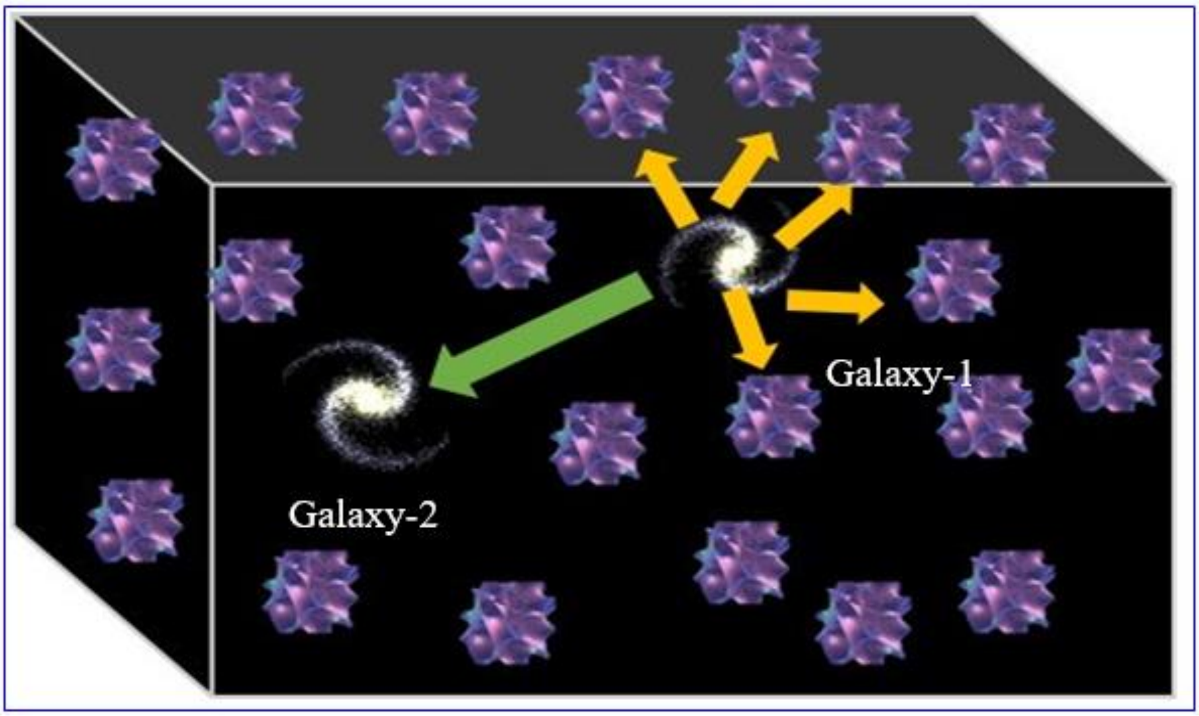

Figure 1. Visual representation of the proposed model. The cuboid represents the observable universe. As we can see, Galaxy-1 is gravitationally pulled by the Galaxy-2 and also attracted by the antiquarks via the strong nuclear force in the Calabi-Yau Space (shown in purple dots).

3. MATHEMATICAL ANALYSIS

According to General Relativity, (1) gives F_G between two galaxies. For $m_1 = 10^{12}$ kg solar mass, F_G is given in Table 1.

$$\ddot{r} = -\frac{Gm_1}{r^2} + r\dot{\theta}^2 - \frac{3Gm_1}{c^2}\dot{\theta}^2 \tag{1}$$

$$\ddot{\theta} = -{}^{2\dot{r}\dot{\theta}}/_{r} \tag{2}$$

Table 1. F_G between two galaxies of identical mass for sveral values of separation (in light years)

Separation (Light Years)	**Gravitational Force, F_G, (N)**
3	3.3×10^{23}
6	8.3×10^{22}
9	3.7×10^{22}
12	2.1×10^{22}

Picard-Fuchs equations, instanton-corrected Yukawa coupling, and the topological one-loop partition function has been applied to the case of complete interactions with higher dimensional moduli spaces [17]. Statistical QCD predicts that strongly interacting matter at sufficiently high density undergoes a transition from hadronic matter to quark-gluon plasma [14]. Basic mechanism for deconfinement in dense matter is the Debye screening of quark colour charge [15]. If the screening radius r_D becomes less than the binding radius r_H of the quark system, i.e., less than the hadron radius, the confinement force fails to hold the quarks together and this results in deconfinement [16]. Therefore, it is suitable to apply Yukawa's nuclear theory to calculate the force between quarks in galaxies and between quarks in extra spatial dimensions.

According to Yukawa's Theory of the Nuclear Force [13]:

$$F_N = \frac{He^{-d/d_0}}{d^2} \tag{3}$$

where: F_N = Strong Nuclear Force H = 1.92570×10^{-25} kgm^3s^{-2}, D_0 = 1.522×10^{-15} m, D = Distance between quarks ($\approx 10^{-15}$ m). Now, approximate number of protons in a galaxy is given by:

$$N_P = M_P/M_G \tag{4}$$

where: Np = number of protons, M_G = mass of the galaxy, M_P = Mass of a proton. Hence, for Milky Way, Np $\approx 1.2\times10^{69}$. Substituting Np = 1.2×10^{69} and F_N = 105 N, total FN $\approx 10^{74}$ N.

Thus, cumulative strong nuclear force is given by:

$$\Sigma FN = 3N_P \tag{5}$$

where: $F_N \approx 105$ N. Hence, for extremely small distances, $F_N > F_G$. Thus, according to our proposed model, the antimatter in Calabi-Yau space is sufficient (assuming 1-1 interaction) to attract the galaxies. Figure 2 and Figure 3 depicts the graphical comparison of specified Force and Seperation time of the proposed model.

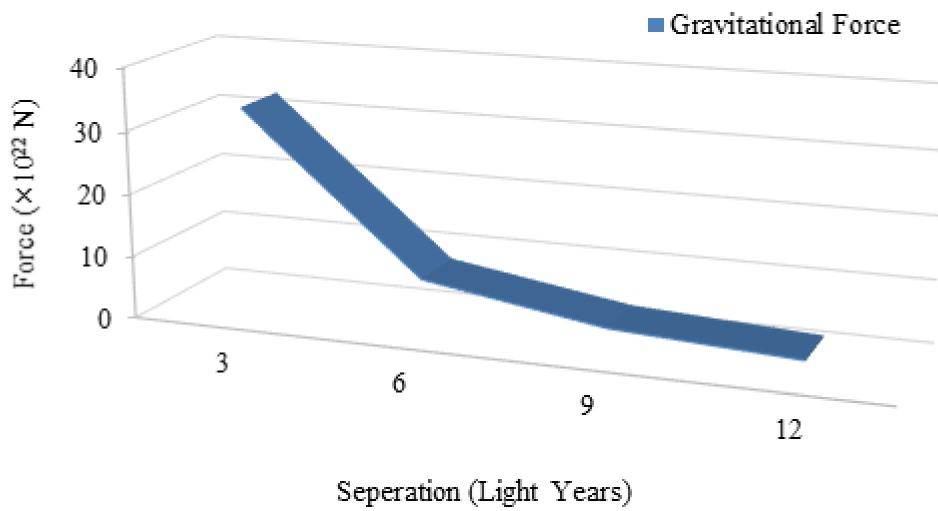

Figure 2. Force vs Seperation plot for the proposed model.

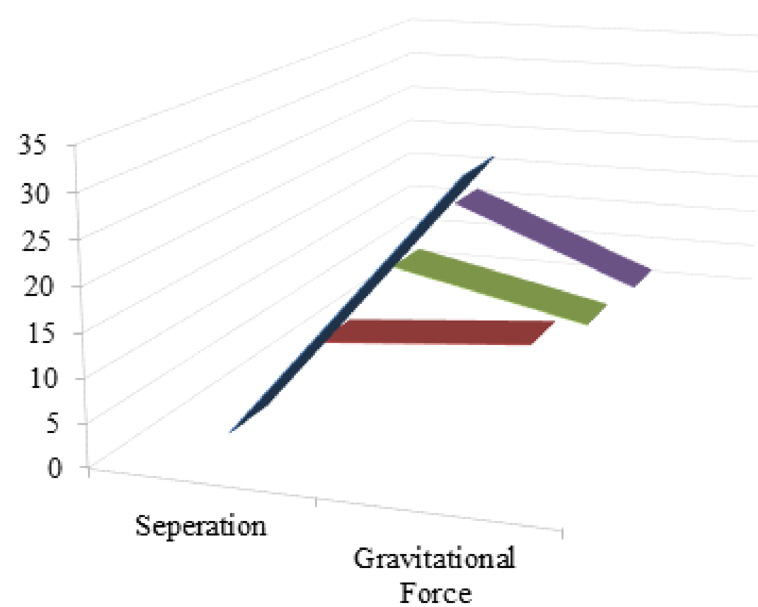

Figure 3. Close comparisn between given seperation to output Force.

4. CONCLUSION AND FUTURE WORK

The proposed model is based on established axioms from previous works. Mathematical analysis shows that over the range considered, strong nuclear force is much larger than gravitational force so as to exercise significant impact on the observed motion of astronomical bodies. Previous works have justified the application of Yukuwa's nuclear theory to estimate the force between antiquarks in Calabi-Yau space and quarks in galaxies. As a result, it is not impossible to propose that the accelerated expansion of the universe is caused by antimatter within the Calabi-Yau space, which may as well be the coveted dark energy. One possible drawback of the proposed model is the annihilation of proton-antiproton, neutron-antineutron pairs, which may occur if the hidden dimensions consist of a large number of baryons. Future work may include evaluating the consequences after incorporating antibaryons in our model.

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