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A new model to explain an accelerating universe within Newtonian mechanics

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Abstract

In this paper, applying only Newtonian mechanics, I have made an analysis of the nature of an accelerating universe. In this model loss of gravitational force replaces any need for dark energy to explain an accelerating universe. This model is consistent with the Big Bang model.

Keywords: **Newtonian mechanics; accelerating universe; gravitational force; dark energy**
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1. Introduction

A review of recent observations suggests that the universe is light weight (matter density is $\frac{1}{3}$ of its critical value) [1, 2], accelerating [3, 4, 5] and flat [6, 7, 8]. This implies the existence of an unknown form of energy which is at present termed as Dark Energy [9, 10]. It is supposed that this unknown energy helps to over come the gravitational self-attraction of galaxies and stars that causes the accelerating expansion of the universe. But, the search for the origin and nature of such till date unknown energy, termed as the Dark Energy, is very challenging and continuing since 1998 when S. Perlmutter and his co-workers first reported such experience in *Nature*. At the very next year (1999) N. A. Bahell; J. P. Ostriker; S. Perlmutter and P.J.Steinhardt draw a similar conclusion in the article published in *Science* [3] while they were studying distant supernovae galaxies. Since then, different cosmological models are reported to account for such acceleration [11, 12, 13, 14]. Cosmological models with different types of dark energies are becoming viable standard models to analyze and simulate experimental data of a number of high red shift supernovae. Einstein's theory of general relativity [15] is unable to explain the presently observed acceleration of the universe, except a negative value of cosmological constant (Λ) which also needs fine tuning to present the universe at its present form. The cosmological constant (Λ) was introduced by Einstein to represent a static universe what was considered before the observation of E. P. Hubble in 1929 [16]. Hubble's observation confirmed an ever expanding universe which was followed by Einstein's historical obligation to quote 'The introduction of cosmological constant by me was a great blunder'; though, it was not exactly. Different models of Λ are studied and proposed which partially explains present observations but not able to terminate the search for the Dark Energy theory.

So far, no one could think that Newtonian laws of motion may demonstrate an accelerating universe even qualitatively. But, surprisingly, it is possible. In this article, an accelerating universe is explained considering a thought experiment where everything is governed by Newtonian mechanics.

2. Observations and discussions on a thought experiment

2.1. a thought experiment

Let us consider, two astronomical objects A and B are moving with a relative velocity u away from each other at any time t when they are separated by a distance D. Let, their masses are m_1 and m_2 respectively. Thus, after a time interval Δt we get

$$v = u + f\Delta t \tag{1}$$

$$D_{\Delta t} = D + u\Delta t + \frac{1}{2} f \Delta t^2 \tag{2}$$

where v is relative velocity of those objects with respect to each other, f is acceleration or deceleration (if exists) and $D_{\Delta t}$ is distance between two objects after time interval Δt. The gravitational attraction force between these two objects at t and $t + \Delta t$ is as follows

$$F_t = G\frac{m_1 m_2}{D^2} \tag{3}$$

$$F_{\Delta t} = G\frac{m_1 m_2}{D_{\Delta t}^2} \tag{4}$$

G is gravitational force constant. Now, change of force is

$$\Delta F = Gm_1 m_2 \{\frac{1}{D^2} - \frac{1}{(D + u\Delta t + \frac{1}{2} f\Delta t^2)^2}\} \tag{5}$$

From Newton's second law of motion we get

$$\Delta F = \frac{m_1 + m_2}{m_1 m_2} f \tag{6}$$

From Equation 5 and 6 we get

$$f = G\frac{(m_1 m_2)^2}{(m_1 + m_2)D^2}\{1 - \frac{D^2}{(D + u\Delta t + \frac{1}{2} f\Delta t^2)^2}\} \tag{7}$$

2.2. observation and discussion

Equation 7 is our focus of interest. As we have considered Newtonian mechanics, m_1, m_2 and D are constant and positive quantity. Δt is real in this formalism. As we have considered a general situation, Equation 7 would be applicable for any two objects in this universe. Depending on the value of f, in Equation 7, nature of the universe could be predicted. Right hand side of the Equation 7 contains f, thus, we can't predict the sign of f without knowing the exact values of D, u and Δt. But, the universal law we are looking for should not depend on numerical values of its parameter. Only one way we can examine the nature of f which is generally known as self consistent method. In this method a guess value is considered for f which is then put in right hand side to get the new value of f from Equation 7. In second step obtained value of f is used as guess. This process is continued until the difference between guess value and obtained value is less than a specified cut off value. To know the sing of f similar approach is followed.

There are three possibilities for the sing of f; positive, negative or 0.

- **(a) (f is +ve):** when f is positive, $(D + u\Delta t + \frac{1}{2} f\Delta t^2)^2 > D^2$, hence right hand side of Equation 7 is positive. Thus, guess and obtained sign of f is consistent. So, we may come to the conclusion that any positive value of f is acceptable.

- **(b) (f is -ve):** When f is negative no direct conclusion could be made. But, we can prove that there are different situations where a negative guess value of f is inconsistent with obtained value. For example, when Δt is small and D is large, a guess value of negative f yields a positive obtained value of f. Thus, we should conclude that negative value of f is not self consistent, hence not acceptable.

- **(c) (f is 0):** When guess value of f is 0, obtained value of f is positive which excludes the possibility of f to be 0.

From above discussions, we confidently claim that in Equation 7, f is always positive which implies accelerating expansion of our universe.

2.3. *Meaning of positive value of f*

In section 2.2, it is found that f is positive which is consistent with our present observations. If f is positive, ΔF is also positive. According to Newton's law of gravity ΔF must be positive since $D_{\Delta t} > D$. But, only a positive value of ΔF doesn't guarantee positive value of f. The value of f is positive only when the acting forces on these two bodies are constant or increasing. From this study we can conclude that if the acting forces are constant or increasing, rate of the acceleration of the universe is also positive. Present method only able to explain the acceleration arises from Newton's law of gravity, not the initial force (or forces) which causes the expansion of the universe. This also silent about the status of that unknown force whether that is a constant, decreasing or increasing. From the energy conservation of the thought experiment discussed here may explain the origin of the unknown force which cause expansion of the universe.

2.4. *Condition for decelerating universe*

In section 2.2, it is proved that our universe is ever expanding universe with acceleration. f could not be 0 or negative in real time *ie.* $\Delta t^2 > 0$. But, if we consider Δt as an imaginary quantity there are possibilities for acceptable values of $f = 0$ and $f < 0$ obeying self consistency of f in Equation 7. Scope for such study is out side of our present discussions as we are dealing with Newtonian mechanics only. Yet, we may have a look to understand the generality of Equation 7. When t is imaginary, *ie.* $\Delta t^2 < 0$, $f = 0$ would be obtained only when

$$D = \frac{u|\Delta t|^2}{2\Delta t} \tag{8}$$

In Equation 8 $|\Delta t|^2$ is real, but Δt is imaginary. Thus, D is imaginary. So, we can say, $f = 0$ state would exists only in imaginary space.

2.5. *value of f for spacial cases*

Now, let us find the value of f in different spacial cases. In all treatment we should consider f as a positive quantity.

- **(a) ($\Delta t \to 0$) :** When $\Delta t \to 0$, we get $f = 0$ which is obvious, but test the correctness of Equation 7.
- **(b) ($\Delta t \to \infty$) :** When $\Delta t \to \infty$ we get

$$f = G\frac{(m_1 m_2)^2}{(m_1 + m_2)D^2} \tag{9}$$

which implies that the acceleration is independent of Δt after a very large time interval. If we consider reduced mass of all objects in our universe is invariant, we should come to the conclusion that after very large time interval, acceleration of any cosmological object would be a function of displacement (D). This conclusion is consistent with our supernovae results which say that redshift (z) of a galaxy is larger for a galaxy which is at a far distance.

3. Conclusions

In present work it is shown that we can observe an accelerating universe within Newtonian mechanics. This model is consistent with experimental observations of high redshift supernovae and Big Bang model. Accelerating expansion of our universe is observed without introduction of any form of dark energy. This is a primary report and only qualitative results are presented. In future, different cosmological constants would be derived using this approach which would help to measure its merits and demerits.

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