Possible Explanations for: (i) The Accelerated Expansion of the Universe and (ii) The Relative Strengths of Gravitational and Electric Forces

HASMUKH K TANK

Indian Space Research Organisation, 22/693, Krishna Dham-2, Vejalpur, Ahmedabad 380 015, India

This paper attempts to propose possible explanations for: (i) the accelerated expansion of the universe and (ii) the relative strengths of gravitational and electric forces. It is proposed here that the cosmological red-shift may be partly a gravitational effect of mass contained in the sphere of radius r, equal to the luminosity-distance D. Based on this, the astronomical observations leading to 'accelerated expansion of the universe' can be explained as follows: When the luminosity-distance D exceeds half the radius of the universe R_0, a part of the sphere of radius D falls outside the sphere of the universe, so the mass contained in it is lesser than expected from the formula: $m = (4/3) \pi \rho_c D^3$, and so the red-shifts go on reducing from its expected values after the red-shift $z_c > 0.5$. We may have been interpreting this as 'the accelerated-expansion of the universe'. Equality of cosmic-gravitational-potential-energy and the sum total of electrostatic-potential-energy stored in the universe seems to decide the relative strengths of gravitational and electric forces. Wave-theoretical-explanation for the observed strength-ratio of gravitational and electric forces is also included.

Key Words: Gravitation; Cosmology; Cosmological-red-shift; Gravitational-red-shift; Accelerated-Expansion of the Universe; Relative Strengths of Gravitational and Electric Forces

1. Introduction

Cosmologists and astrophysicists are currently engaged in solving two major puzzles, put forward by nature in the form of the following experimental observations: (i) There are not enough visible stars or gas inside galaxies to account for their high rate of rotation and the observed 'flattening of galaxies rotation-curves'. Theory of 'dark-matter, and Modified Newtonian Dynamics [MOND] are the currently considered approaches to explain this phenomenon. (ii) The second puzzle came from the observations of a very specific kind known as a Type Ia supernova: when they were compared in distant *vs* nearby galaxies, it was found that the distant supernovae were fainter, and thus farther away than expected. This implied that the universe was not only expanding, but accelerating its expansion. In 1998, observations of Type Ia supernovae suggested that

the expansion of the universe has been accelerating since around red-shift of z ~ 0.5 [1, 2]. In the past few years, these observations have been corroborated by several independent sources: the cosmic microwave background radiation and large scale structure [3] age of the universe [4] as well as improved measurements of the supernovae [5, 6] and X-ray properties of galaxy clusters. Currently popular theories attempting to explain 'accelerating expansion' include some form of dark energy: Cosmological-constant, Quintessence, Dark-fluid or Phantom-energy. The most important property of dark energy is that it has negative pressure which is distributed relatively homogeneously in space.

Since the exact nature of dark-matter and dark-energy are not yet perfectly known, this author had earlier proposed a 'wave-theoretical-explanation' for the 'galaxies-rotation-curves' [10]. This letter

*Author for Correspondence: E-mail: tank.hasmukh@rediffmail.com

proposes a very simple possibility for 'the accelerated-expansion of the universe as follows: The 'cosmological-red-shift' may be partly a gravitational effect caused by mass contained in the sphere of radius r equal to the 'luminosity-distance' D between the light-emitting-star and the observer-on-earth; so, when the light-emitting star is farther than half the radius of the universe, a part of the sphere-of-radius $r = D$ falls beyond the border of the universe which is a sphere of radius R_0. So, the mass contained in the sphere of radius D larger than half the radius of the universe is comparatively lesser than expected from the formula: $m = (4/3) \pi\rho_c D^3$. So the cosmological-red-shift of light emitted by the stars farther than half the radius of the universe, go on reducing with luminosity-distance; which we may have been interpreting as 'the accelerated-expansion of the universe'.

Then it is proposed here that: sum-total of gravitational-potential-energy of the universe seems to be equal to the sum-total of electrostatic-potential-energy of the universe; it is this equality which leads to the observed strength-ratio of gravitational and electric forces. To substantiate this hypothesis, a 'wave-theoretical-explanation' for the observed strength-ratio of gravitational and electric forces is also included.

2. Mathematical Derivations

2.1 Accelerated-expansion of the Universe

Let us assume that the 'cosmological-red-shift' is partly a gravitational-effect. The photon emitted by a supernova, and reaching us on earth, experiences some gravitational pull from the mass within the sphere of radius r equal to the 'luminosity-distance' D. The change in gravitational-potential-energy of a body of mass m will be:

$$\Delta E = G (4/3) \pi\rho_c D^3 m/D,$$

where,

ρ_c is average density of matter in the universe;

$\rho_c = 3H_0^2/(8\pi G) = 9.6 \times 10^{-27}$ kg-m^{-3}; [Ref. 3]

i.e. $\Delta E = [G(4/3) \pi\{3H_0^2/(8\pi G)\} D^3 m]/D$

i.e. $\Delta E = (1/2) (m) H_0^2 D^2$ \hfill (1)

Now by translating this gravitational-potential-energy into the kinetic energy of body of mass m:

$$(1/2) mv^2 = (1/2) (m) H_0^2 D^2$$

i.e. $v = H_0 D$ \hfill (2)

We may have been interpreting this velocity as the 'recessional-velocity' of the galaxies.

The expressions (1) and (2) are correct as long as the 'luminosity-distance' D is smaller than $R_0/2$; that is, for the cosmological-red-shifts up to 0.5; but when $D > (R_0/2)$, a part of the sphere of radius D falls outside the sphere of the universe; so the mass contained in the sphere starts deviating from the expression: $(4/3) \pi\rho_c D^3$. So we observe lesser red-shifts than expected from the distant supernovae.

Similarly, we can derive the expression for acceleration:

$$a = G (4/3) \pi\rho_c D^3/D^2$$

i.e. $a = G (4/3) \pi \{3H_0^2/(8\pi G)\} D$

i.e. $a = (0.5) H_0^2 D$ \hfill (3)

This expression of acceleration is strikingly similar to the experimentally observed value:

$$a = (0.6) H_0^2 D. \quad [\text{Ref. 1,2}]$$

(Note: From the view-point of the historical development, the 'cosmological-red-shift' was observed first; and based on it the total-mass and radius of the universe were estimated. But we know that there is almost homogenous and isotropic distribution of matter in the universe; and as per Newton's shell-theorem, the mass contained within the sphere is bound to gravitationally affect the photon, so we started here from the density-of-the-universe to derive the 'cosmological-red-shift', and the accelerated-expansion of the universe. Experimental-physicists and theoretical-physicist approaching from opposite directions, meeting and shaking hands in agreement; and greeting.)

2.2 Possible-explanation for the Relative Strengths of Gravitational and Electric Forces

The reader must have seen the crackers, known in Hindi as '*Prithvi-chaskra*' which spin at very high rate when lit; and they get levitated against gravity as their spinning-speed increases. Similarly, the spinning motion of the electrons and the protons contained in all the atoms in the universe may be counteracting the gravitational-pull of all the atoms in the universe. So, in the quantitative terms, the gravitational-potential-energy of the universe seems to be equal to the total electrostatic-potential-energy stored in all the atoms in the universe. From my earlier attempts [7-9] it was found that: if the electrostatic potential-energy stored in the universe is equal to the gravitational-potential-energy of the universe, which is also equal to the energy-of-mass of the universe, then the relative strengths of gravitational and electric forces will be as we already observe experimentally: That is, since:

$$GM_0 \, M_0/R_0 = M_0 c^2 = U_E, \qquad (4)$$

where, G is gravitational-constant, M_0 is total-mass of the universe, R_0 is radius of the universe, and c is speed of light in vacuum, and U_E is total amount of electrostatic-potential-energy stored in the universe.

Now dividing all the three sides of the expression (4) by 1836×10^{80} :

i.e. $\quad GM_0 \, m_e/R_0 = m_e \, c^2 = e^2/r_e$

i.e. $\quad 10^{80} \, Gm_p m_e/10^{40} \, r_e = m_e \, c^2 = e^2/r_e$

Because, from the Large Number Coincidence [LNC] we know that [7]:

$$M_0/m_p = 10^{80}, \, R_0/r_e = 10^{40} \text{ and } e^2/r_e = m_e c^2$$

i.e. $\quad (e^2/Gm_p \, m_e) = 10^{40} \qquad (5)$

Thus the observed strength-ratio of gravitational and electric forces leads to equality of gravitational-potential-energy of the universe and the electrostatic-potential-energy contained in all the atoms of the universe. Or, it is the equality of cosmic-gravitational-potential-energy and electrostatic-potential-energy stored in all the atoms of the universe which has led

to the observed strength-ratio of gravitational and electric forces.

3. Wave-theoretical Explanation for the Relative Strengths of Gravitational and Electric Forces

In the recurrences of Dirac's large-number-ratios we find that the strength-ratio ($e^2/G \, m_e m_p$) and the radius-ratio (R_0/r_e) are equal; and proportional to the *square-root* of the mass-ratio $(M_0/m_p)^{1/2}$. This can be explained with the help of wave-theory as follows [10]:

We can take the mass of the 'most-fundamental-particle' as a unity, and think that all the massive objects are collections of the 'most-fundamental-particles'.

Now, by a 'particle' we mean an entity localized in an extremely small space; so, a 'particle' can be mathematically represented in the space-domain as an impulse-function. This impulse-function can be Fourier-transformed into the 'wave-number-domain'. Then assuming a constant velocity of transmission of these waves, at the velocity of light, we can represent these waves in the 'frequency-domain' as a wide band of frequencies. A particle of matter has a wide band of frequency-spectrum and a definite phase-spectrum. When this wide-band-of-waves travels in space, then a 'particle' becomes manifest only at a place and time when-and-where all the spectral-components have a particular, definite phase-relation, otherwise the particle remains dissolved in the un-manifest-state.

Secondly, we can not expect any coherence between the spectral-components of one and the other 'particle'. That means, that when two or more such fundamental-particles come close to each-other, the wide bands of their waves add like the incoherent superimposition of wideband-noise. We know that the superimposition of n number of wide-band noise-sources of unit-amplitude is square-root-of n; like the vector-sum of n mutually orthogonal unit-vectors.

Now, if the strength of a fundamental-force operating within a single fundamental-particle, say proton, is e^2, which is the strength of electric-force of the proton, then the strength of new fundamental-

force per particle within the system of n fundamental-particles will be: $[(n^{1/2}e^2)/n]$. For example, since the mass-of-the-universe is 10^{80} proton-masses, the strength of gravitational-force between the two protons is:

$$G\, m_p{}^2 = [10^{80}]^{1/2}\, e^2/[10^{80}] = 10^{-40}e^2 \qquad (6)$$

Now, if the attractive-force within a system is stronger than gravity by a multiplication-factor, say, k-times, then the density of matter within that system is also logically expected to be k-times higher. That is, in our example of proton and the universe:

$$e^2/G\, m_p{}^2 = [\,M_0/m_p]^{1/2}$$
$$= [m_p/(4/3)\pi\, r_p{}^3]/[M_0/(4/3)\pi\, R_0{}^3]$$

i.e. $e^2/G\, m_p{}^2 = [\,M_0/m_p]^{1/2} = [m_p\, R_0{}^3/M_0\ r_p{}^3]$

i.e. $[M_0/m_p]^{3/2} = [R_0{}^3/r_p{}^3]$

i.e. $[M_0/m_p]^{1/2} = [R_0/r_p] = e^2/Gm_p{}^2 \qquad (7)$

This is how we can explain the LNC and the relative strengths of gravitational and electric forces with the help of 'wave-theory'.

References

1. Riess A *et al*. *Astronomical J* **116** (1998) 1009

2. Perlmutter S *et al*. *Astrophysical J* **517** (1999) 565

3. Spergel DN *et al*. *Astrophysical J Suppl* **148** (2003) 175

4. Chaboyer B and Krauss LM *Astrophysical J Letters* **567** (2002) L4

5. Wood-Vasey WM *et al*. *Astrophysical J* **666** (2007) 694

6. Astier P *et al*. *Astronomy* & *Astrophysics* **447** (2006) 31

7. Tank HK Explanation for the recurrences of large-number 10^{40} in astrophysics, and some insight into the nature of fundamental forces *Proc Indian National Science Academy* **63A(6)** (1997) 469-474

8. Tank HK A new law emerging from the recurrences of the "critical-acceleration" of MOND, suggesting a clue to unification of fundamental forces, *Astrophysics & Space Sci* **330** (2010) 203-205

9. Tank HK An Explanation for the Relative Strengths of 'Gravitational' and 'Electric' Forces Suggesting Equality of the 'Electrostatic'-potential-energy', 'Gravitational-potential- energy' and 'Energy of Mass' of the Universe *Sci & Cult* **75** (2009)

10. Tank HK Wave-theoretical explanation for the newly-emerged-law of equality of potential-energy and energy-of-mass of reasonably independent systems of matter, *Advanced Studies in Theoretical Physics* **5** (2011) 45-55.