

# Is the expansion of universe accelerating or the Photons decelerating?

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## Abstract

Astronomical observations of the cosmological red-shift are currently interpreted in terms of 'expansion of universe' and 'accelerated-expansion of the universe', at the rate of  $H_0 c$ ; here  $H_0$  is Hubble's constant, and  $c$  is the speed of light. Whereas a straight-forward derivation presented here suggests that: rather it is the photon which is decelerating, at the rate of  $H_0 c$ . Such a deceleration of photons can be caused by virtual electrons, positrons and pi-mesons, contained in the extra galactic quantum vacuum, because: they do have gravitational-acceleration of the same order as  $H_0 c$  at their "surfaces"; or by decay of a photon into a lighter photon and a particle of mass  $h H_0 / c^2$ . Tired-light interpretations of the cosmological red-shift were so far considered as not compatible with the observations of 'time-dilation of super-novae light-curves'; so in a paper titled: "Wave-theoretical insight into the relativistic 'length-contraction' and 'time-dilation of super-novae light-curves'" (Tank, Hasmukh K. 2013), it has been already shown that any mechanism which can cause 'cosmological red-shift' will also cause 'time-dilation of super-novae light-curves'. Therefore, we now need not to remain confined to the Big-Bang model of cosmology.

**Keywords:** Cosmology; Cosmological Red-Shift; Accelerated Expansion of the Universe; Steady-State-Cosmology.

## 1. Introduction

E.P. Hubble's observations of 'cosmological red-shift', and subsequent observations till today, are currently interpreted in terms of 'expansion of the universe' and accelerated-expansion of the universe at the rate  $H_0 c$ . Whereas a straight-forward derivation presented here suggests that: rather it is the photon which is decelerating, at the rate of  $H_0 c$ . Tired-light interpretations of a cosmological red-shift were so far considered as not compatible with the observations of 'time-dilation of super-novae light-curves'; so in a paper titled: "Wave-theoretical insight into the relativistic 'length-contraction' and 'time-dilation of super-novae light-curves'" (Tank, Hasmukh K. 2013) it has been already shown that any mechanism which can cause 'cosmological red-shift' will also cause 'time-dilation of super-novae light-curves'. Therefore, we now need not to remain confined to the Big Bang model of cosmology.

Martin Lopez-Corredoira (2014) applied Alcock- Paczynski cosmological test to six candidate cosmological models; and reached a conclusion that only two of them, namely lambda-CDM and static universe with tired light interpretation of the cosmological red-shift, fit the data.

Cosmologists have accepted the 'space-expansion- interpretation' of the 'cosmological red-shift', as it matches with Einstein's General Theory of Relativity (GR), which predicted 'expansion of space'. This author has been arguing that 'expansion of space' of GR is a 'mathematical terminology' not a physical phenomenon; because: as per GR, if the space between the galaxies is expanding, but the space within the galaxy is not doing so, as a galaxy is a gravitationally-bound structure, then what happens at the boundary of the galaxy? Such uneven expansion of glass would break

the glass, and may tear off the space, if expansion-of-space were a physically-real phenomenon. Recently, Ling Jun Wang, (2014) in an article, "On the Flatness of Space-time" has rigorously proven that curvature and expansion of space-time are mathematical entities, not the physically real curvature or expansion of space. So, the static universe with tired-light explanation has remained the only candidate. In this paper 'cosmological red-shift' is explained in terms of deceleration of photons caused by virtual electrons and pi-mesons contained in the extra galactic quantum vacuum. And, as supportive evidence, it is shown here that virtual electrons and pi-mesons do have gravitational-acceleration of the order  $H_0 c$  at their "surfaces." As a further supportive evidence for this proposal, it is shown that even the space-probes Pioneer-10, Pioneer-11, Galileo and Ulysses too, did decelerate at the same rate  $H_0 c$  (Anderson J.D. at all 1998).

## 2. The derivations

- i) It is currently believed that the expansion of the universe is getting accelerated at the rate  $H_0 c$ . The following derivation suggests that rather it is the cosmologically red-shifting photon, which is decelerating at the same rate. The linear part of the cosmological red-shift is expressed as:

$$z_c = h \Delta f / h f = H_0 D / c$$

That is, the loss in energy of the photon, at a distance  $D$ , is:

$$h \Delta f = (h f / c^2) (H_0 c) D \quad (1)$$

That is, the loss in energy of the photon at a distance  $D$  is equal to its “mass” times the acceleration ( $H_0 c$ ) times the distance  $D$ . Whether the expansion of the universe is accelerating, is still a hypothesis; whereas the cosmologically red-shifting photon is decelerating at the same rate ( $H_0 c$ ), as found here, is an experimentally observed fact.

The mechanisms, which can cause such a deceleration of the photons, can be explained as follows:

- a) The inter-galactic space is not a void extension of nothingness. As per quantum mechanics, pairs of virtual particle-and-antiparticles keep on coming in existence for small durations of time permitted by ‘Heisenberg’s uncertainty principle’. There are many pairs of virtual particles always present in the path of inter-galactic photons. The gravitational-acceleration at the “surface” of these particles is of the order of  $H_0 c$  as shown below: So all these virtual particles, bit by bit, keep on causing ‘gravitational red-shift’ in the inter-galactic photons.

Gravitational acceleration at the “surface” of the electron:

$$a_e = G m_e / (e^2 / 2 m_e c^2)^2 = H_0 c \quad (2)$$

Gravitational acceleration at the surface of the pi-meson can also be derived from Steven Weinberg’s formula, that:

$$m_{pi} = [h^2 H_0 / c G]^{1/3}$$

$$\text{i.e. } G m_{pi} / (h / m_{pi} c)^2 = H_0 c \quad (3)$$

Even the accelerations at the “surface” of the nucleus-of-atom, the globular-clusters, the spiral-galaxies, and the galactic-clusters too, are of the order of  $H_0 c$  as Siveram C. (1994) has numerically found:

- i) For a typical atomic nucleus of mass  $m_n$ , ( $A = 150$ )

$$a = G m_n / r_n^2 \sim 1.0 \times 10^{-10} \text{ m / s}^2$$

- ii) For a globular cluster of mass  $10^6$  solar-masses and radius  $R_g = 100$  pc,

$$a = G M_g / R_g^2 \sim 10^{-10} \text{ m / s}^2$$

- iii) For a spiral galaxy of mass  $M_{gal} = 10^{12}$  solar-masses and radius  $R_{gal} = 30$  kpc,

$$a = G M_{gal} / R_{gal}^2 \sim 0.8 \times 10^{-10} \text{ m / s}^2$$

- iv) For a typical cluster of galaxies,  $M_c = 10^{16}$  solar-masses and radius  $R_c = 3$  Mpc,

$$a = G M_c / R_c^2 \sim 10^{-10} \text{ m / s}^2$$

- v) Also, for the observable-universe as a whole, with a density of  $10^{-29}$  grams/cm<sup>3</sup> and radius  $R_0 = 10^{28}$  cm,

$$a = H_0 c = 6.87 \times 10^{-10} \text{ m/s}^2$$

- vi) And the value of ‘critical acceleration of MOND,

$$a_0 \sim 10^{-10} \text{ m / s}^2$$

- ii) As a supportive evidence for the above theory, let us look at the values of decelerations experienced by Pioneer-10, Pioneer-11, Galileo and Ulysses space-probes, (Anderson J.D. et al. 1998):

$$1) \text{ For Pioneer-10, } a = (8.09 \pm 0.2) \times 10^{-10} \text{ m / s}^2$$

$$2) \text{ For Pioneer-11, } a = (8.56 \pm 0.15) \times 10^{-10} \text{ m / s}^2$$

$$3) \text{ For Ulysses, } a = (12 \pm 3) \times 10^{-10} \text{ m / s}^2$$

$$4) \text{ For Galileo, } a = (8.0 \pm 3) \times 10^{-10} \text{ m / s}^2$$

All these decelerations are of the same order of magnitude as  $H_0 c = 6.87 \times 10^{-10} \text{ m/s}^2$ ; and match strikingly with the ‘critical-acceleration’  $a_0$  of MOND; an extremely rare-probability coincidence. Matching of four different decelerations of the space-probes, in spite of the differences in their mass, velocities and directions, is itself a striking coincidence; and its matching with the deceleration experienced by the ‘cosmologically red-shifting photon’ cannot be ignored by a scientific mind as a coincidence. So the atoms contained in the space-probes got decelerated due to the bit-by-bit decelerations caused by the virtual particles. This mechanism is testable in the laboratory. Or:

- b) By decay of a photon into a lighter photon and a particle of mass  $h H_0 / c^2$ , at every wavelength traveled by the photon. Experimental detection of a new particle of such a small mass may be difficult but not impossible for the physicists. One of the ways of predicting a new particle is to calculate the missing energy, by applying the law of conservation of energy. The photon does loose a chunk of energy  $h H_0$  while traveling every distance equal to its wavelength. This method suggests that a particle of mass  $h H_0 / c^2$  is likely to exist, based on the following argument: The strength ratio of electric forces and strong forces is  $\sim e^2 / h c$ , and we do find particles of the similar mass-ratio, namely, the mass-ratio of the electron and the pi-meson:  $(m_e / m_{pi}) \sim (e^2 / h c)$ . Similarly, we can expect the particles with a mass-ratio:  $(h H_0 / c^2) / m_e = [(G m_e m_{proton}) / (e^2)]$ . Interestingly the ratio  $(h H_0 / c^2) / m_e$  is indeed equal to the ratio  $[(G m_e m_{proton}) / (e^2)]$ ! Therefore, our expectation of a particle of mass:  $(h H_0 / c^2)$  is quite reasonable.

### 3. Summary

The straight-forward derivation presented here suggests that: the extra-galactic photons are decelerating at the rate  $H_0 c$  is an experimentally-observed fact. The gravitational acceleration at the “surface” of the virtual electrons, virtual positrons and virtual pi-mesons is also of the same order of magnitude as  $H_0 c$ , so the gravitational field of the virtual particles bit-by-bit can keep on causing ‘gravitational red-shift’ in the extra-galactic photons. This reduction in the energy of the photons can explain the observation of ‘cosmological red-shift’. This mechanism is testable in the laboratory. Possible alternative mechanism proposed here is: decay of the photon into a lighter photon and a new particle of mass:  $(h H_0 / c^2)$ .

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