Some questions regarding general relativity theory: And the cosmological red-shift

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Abstract:

This paper raises some questions regarding general theory of relativity like: (i) the theory predicts 'expansion of space' between the galaxies; but the space within the galaxy is not expanding, because galaxy is a gravitationally-bound-structure. The question raised here is: If so, then what happens at the edge of a galaxy whose external space is expanding but the space within is not expanding? Is there a smooth transition from expanding to non-expanding space? And what happens to the cosmologically red-shifted inter-galactic-photons when they enter our milky-way galaxy from expanding outer-space to less-and-less expanding space within our galaxy? (ii) According to general relativity the planets, like the earth, orbit around the Sun, because the space around the Sun has got curved; and the planets are in inertial-motion travelling along the geodesic path. Now the question raised here is: Inertial-motion of a body can be at any speed. Can the planets travel along the geodesic-path at any speed they like? Can they take a coffee-brake and then proceed further? (iii) According to general relativity there is a distance at which rate of expansion of space is equal to the speed of light; and the speed of light is always the same, 3×10^8 meters per second. The question raised here is: Since the speed of light is the same in expanding as well as non-expanding space; and $f \cdot \lambda = c$, i.e. the product of frequency (f) and wavelength (λ) is always equal to the speed of light (c); then the wavelength (λ) can increase only when frequency (f) gets reduced; and not because of expansion of space. Then in the second part of the paper it is shown that reduction in energy of 'cosmologically red-shifting photons' is strikingly equal to ($G\ m_e\ m_p\ /\ e^2$) times the reduction in electrostatic potential-energy of an electron at the same distance D.

Introduction:

Einstein's theory of relativity talks of 'contraction of length', 'dilation of time', and 'curvature' and expansion of space. 'Length' of an object is something physical and objective, so length can be measured using a foot-rule. But 'time' is not a physical entity, it is just a mental abstraction. We conventionally talk of 'time' by observing and comparing cyclically repeating physical processes. So talking about dilation of 'time', and measuring it using two atomic clocks at different heights, only means that physical processes within the atomic clocks get affected by gravity; and not dilation of 'time'. And since a decaying particle moving at high speed contains additional energy, namely 'kinetic energy', so it takes longer time to decay! Like this author many scientists have been raising questions against the general-relativistic 'expanding model of the universe'; as can be found from the innumerable peer-reviewed papers. According to Prof. Jayant Narlikar there is too much extrapolation of various formulae in the expanding model, which may not be correct. Another question, raised by some scientists is: Is energy conserved in GR? Some other scientists have gathered one hundred questions against relativity theory. Einstein's reply was: "One question is sufficient for fall of my theory". This author proposes to the open minded scientists to consider whether one of the questions raised in the abstract is not answerable by the general relativity theory? The questions are elaborated in the next section.

The questions:

(i) The general theory of relativity predicts 'expansion of space' between the galaxies; but the space within the galaxy is not expanding, because galaxy is a gravitationally-bound-structure. The question raised here is: If so, then what happens at the edge of a galaxy whose external space is expanding but the space within is not expanding? Is there a smooth transition from expanding to non-expanding space? And what happens to the cosmologically red-shifted inter-galactic-photons when they enter our milky-way galaxy from expanding outer-space to less-and-less expanding space within our galaxy? If expanding space can increase the wavelength of a photon, then less-and-less expanding space at the boundary of our milky-way galaxy should shrink the wavelength back to its original value, isn't it?

(ii) According to general relativity theory the planets, like the earth, orbit around the Sun, because the space around the Sun has got curved; and the planets are in inertial-motion travelling along the geodesic path. Now the question raised here is: Inertial-motion of a body can be at any speed. Can the planets travel along the geodesic-path at any speed they like? Can they take a coffee-brake and then proceed further?

(iii) According to general relativity there is a distance at which rate of expansion of space is equal to the speed of light; and the speed of light is always the same, 3 x 10^8 meters per second. The question raised here is: Since the speed of light is the same in expanding as well as non-expanding space; and $f \,.\, \lambda = c$, i.e. the product of frequency (f) and wavelength (λ) is always equal to the speed of light (c), then the wavelength (λ) can increase only when frequency (f) gets reduced; and not because of expansion of space.

Part II

P.A.M. Dirac, after receiving the Nobel Prize, when he was on world tour, he got an idea, that: We measure physical quantities in arbitrarily chosen units like: meter, kilogram and seconds. We should use some standard physical length, like the 'classical radius of an electron' (r_e) , to measure lengths. As soon as he expressed the 'radius of the universe' R_0 in terms of 'radius of an electron', to his pleasant surprise the ratio (R_0 / r_e) turned out to be equal to the ratio ($e^2/ G\, m_e\, m_p$) = 10^{40}. And Eddington found that the ratio $(M_0 / m_p) = (e^2/ G\, m_e\, m_p)^2 = 10^{80}$; here M_0 is 'total mass of the universe' and m_p is mass of a proton. Though Dirac's 'Large Number Hypothesis', predicting reduction of 'strength of gravity' with age of the universe, did not match with observations. But the numerology of the above 'Large Number Coincidence' has been striking. Later in 1997 this writer showed that this coincidence implies that: Mass of the universe is equal to gravitational potential-energy of the universe; and electro-static potential-energy stored in an electron is equal to energy of mass of it [1]. While discussing 'classical radius of an electron' E.W. Wichhman, the author of volume-4 of Berkeley physics course, writes "We have derived classical radius of an electron as $r_e = e^2/m_e\, c^2$; though the ghost of infinite self-energy of an electron is still hovering over some scientists." So the conclusion of my paper [1], that electrostatic-energy stored in an electron is equal to energy of mass of it, may have freed the ghost from those scientists! We intend to use here the 'large-number-coincidence', (not the large-number-hypothesis predicting reduction of strength of gravity with time) to reach an interesting conclusion.

Similarly Max Planck tried to derive natural units, of mass, length and time, purely from the fundamental physical constants; but Planck's unit of mass did not match with mass of any physically observed particle; and his unit of length did not match with Compton wavelength of any particle. Later this writer showed [2] that Planck's unit of mass is 'geometric mean value' of two different masses, namely 'total mass of the universe' M_0 and smallest conceivable mass ($h\, H_0 / c^2$); and similarly Planck's length and time. It may be interesting to see that: just as the 'fine-structure-constant' ($e^2/ h\, c$) = (m_e / m_{pion}), so exactly the ratio [($G\, m_e\, m_{proton}$)/ (e^2)] = [($h\, H_0 /c^2$) / m_e)] , so it can be termed as 'very-fine-structure-constant'. So the mass ($h\, H_0 / c^2$) seems to be of significance. It may be the mass of a neutrino or the graviton or some new particle.

Following the line of thinking of Planck, Steven Weinberg tried to derive a fundamental unit of mass by taking four different fundamental constants, including H_0 , and got a value of mass quite close to the mass of a fundamental particle [3]. He found that:

$m_p^3 = h^2 H_0 / c\, G,$ ……………………………………………………………..(1)

Here H_0 Hubble's constant. And the value of mass m_p turned out to be close to the mass of a fundamental-particle, pi meson. Alternatively, m_p^3 can be viewed as m_{proton} x m_{proton} x $m_{electron}$. Weinberg's relation can be written in a meaningful manner as:

$G\, m_p^2 / (h / m_p\, c) = h\, H_0$ …………………………………………………..(2)

where ($h / m_p\, c$) can be taken as a 'fundamental-unit of length'; and the quantity $h\, H_0$ as the 'smallest chunk of energy'.

Based on the above preparatory discussion, we can now re-consider the 'cosmological red-shift'.

(i)

The linear part of the 'cosmological red-shift' is expressed as:

$z_c = (\Delta \lambda / \lambda_0) = (H_0\, D / c)$ ………………………………………………….(3)

The right-hand-side of expression-3 can be written as:

$H_0\, D / c = h\, H_0 / (h\, c / D)$ …………………………………………………(4)

Based on Weinberg's relation: $m_p^3 = h^2 H_0 / c\, G$, which we have re-written in a meaningful manner as: [($G\, m_p^2$) / ($h / m_p\, c$)] = ($h\, H_0$), the 'cosmological red-shift' can be expressed as:

$z_c = \Delta \lambda / \lambda_0 = [G\, m_p^2 / (h / m_p\, c)] / [h\, c / D]$. …………….....….............(5).

i.e. $z_c = \Delta \lambda / \lambda_0 = [G\, m_p^2 / h\, c] [D / (h / m_p\, c)]$ ……………………….....(6).

where ($h / m_p\, c$) is a unit of distance, measured in terms of Compton-wavelength of pi-meson; and the constant [$G\, m_p^2 / h\, c$] denotes the strength-ratio of gravitational and electric forces.

Or, in terms of energy:

$z_c = h\, \Delta \nu / h\, \nu =$ [$G\, m_p^2 / h\, c$] [$D / (h / m_p\, c)$]. ……………….……....(7).

That is, the reduction in energy of photon due to cosmological-red-shift is proportional to the strength-ratio of gravitational and electric forces.

(ii)

Alternatively, let us define reduction in electrostatic potential-energy of an electron-proton-system z_e as:

$z_e = [\, e^2 / r_\mathrm{e} \,] - [\, e^2 / (\, r_\mathrm{e} + D)] \,/\, [\, e^2 / (\, r_\mathrm{e} + D)]$,

where e is electric-charge, r_e is 'classical radius of electron' and D is 'luminosity distance'

i.e. $z_\mathrm{e} = e^2 \,[\, r_\mathrm{e} + D - r_\mathrm{e} \,]\,[\, r_\mathrm{e} + D] \,/\, [\, r_e \,(\, r_e + D)\, e^2 \,]$.

i.e. $z_\mathrm{e} = D / r_\mathrm{e}$. …………………………………………………………….(8)

From the 'Large-Number-Coincidence' , we know, that:

$(G\, m_e\, m_\mathrm{p} / e^2) = (\, r_\mathrm{e} / R_0\,) = (\, m_p / M_0\,)^{1/2} = 10^{-40}$,

Where M_0 is total mass, and R_0 radius of the universe.

i.e. $z_\mathrm{e} = 10^{40}\,(\, D / R_0\,)$. ……………………………………………………..(9)

Since R_0 is defined as a distance at which the velocity $H_0\, D = c$, the product $H_0\, R_0 = c$;

Therefore, $z_\mathrm{c} = H_0\, D / c = D / R_0$ ……………………………………….…(10)

From the expressions (8), (9) and (10), we get:

$z_\mathrm{c} = 10^{-40}\, z_\mathrm{e}$. ……………………………………………………………..(11)

That is: 'cosmological-red-shift, at a distance D is $(G\, m_e\, m_p / e^2)$ times the reduction expected from the 'electrostatic potential energy of an electron at that distance D. This finding can be explained either by invoking 'virtual electrons', which absorb and re-emit the photon's energy, and go to higher and higher orbits; subtracting only the gravitational-potential-energy part. Or we can consider the following hypothesis:

When an electron in an atom falls from higher orbit to a lower orbit a photon gets emitted. Since the electrostatic potential-energy of the electron is negative, because of the attractive force between the proton and the electron, the fall of electron makes its potential-energy more negative. So, based on the 'law of conservation of energy' of an isolated system, we can argue that the energy of the emitted photon is a chunk of positive potential-energy; and since the photon is electrically neutral, it can feel only the gravitational force. Therefore, the photon emitted by an atom might be feeling a repulsive gravitational force; and so it always moves away from the emitting atom. As this photon moves away from the atom, its potential-energy goes on reducing. Since a photon is a chunk of positive potential energy, when it is absorbed by any electron in another atom, the electron's potential energy gets increased; and so, it jumps to higher orbit. The reduction in energy of 'cosmologically red-shifting photon' may be due to this loss of potential energy of the photon.

(iii)

Let us find the reduction in energy of a cosmologically red-shifting photon at a small distance equal to the Compton-wavelength (λ_C) of a fundamental-particle:

$z_c = (h\, \Delta\, \nu \,/\, h\, \nu) = (H_0\, \lambda_C \,/\, c) = (h\, H_0 \,/\, h\, \nu)$

i.e. $(h\, \Delta\, \nu) = (h\, H_0)$ ……………………………………………(12)

i.e. The reduction in energy of a cosmologically red-shifting photon at a distance equal to the Compton-wavelength of a fundamental-particle (λ_C) = $h\, H_0$

And from the expression- 2 we found that gravitational potential-energy of that fundamental-particle, at a distance equal to its Compton-wavelength is also equal to $h\, H_0$:

" $G\, m_p^2 \,/\, (h \,/\, m_p\, c) = h\, H_0$ ………………………………………………(2)"

So, from the expressions (12) and (2) we find that the loss in energy of a cosmologically red-shifting photon is equal to the gravitational potential-energy of it at the same distance λ_C .

(iv)

It is currently believed that the expansion of the universe is getting accelerated at the rate $H_0\, c$. The following derivation suggests that the cosmologically red-shifting photon can also be viewed as decelerating at the same rate:

$z_c = h\, \Delta\, \nu \,/\, h\, \nu = H_0\, D \,/\, c$

i.e. The loss in energy of the photon at a distance D is:

$h\, \Delta\, \nu = (h\, \nu \,/ c^2)\, (H_0\, c)\, D$ …………………………………………………(13)

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 ($H_0\, c$), is a consistently observed fact.

Conclusion:

Current thinking of the majority cosmologists, that 'big-bang-cosmology' is the only model, needs to be made more open-minded. The alternative interpretation of the 'cosmological red-shift' proposed here, that the photon may be getting repelled by the source atom and losing its gravitational potential energy, needs to be considered with an open mind.

References:

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[2] Tank Hasmukh K. "An insight into Planck's Units…." *Progress in Physics* **4** (October 2011) pp- 17-19 URL www.ptep-online.com/index_files/2011/PP-27-04.PDF

[3]] Weinberg S. "Gravitation and Cosmology" (1972) John Willy and Sons, New York