Highest Redshift in Cold Cyclic Cosmology

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Abstract

Our realistic non-singular approach to cosmology predicts an upper bound to measurable cosmic redshifts. This corresponds to the lowest possible scale where the density of electromagnetic radiation equates the density of matter. We examine the highest possible redshifts that correspond to a cold cyclic cosmology where galaxies survive to remain the main protagonists forever. A tight range for highest redshift like $11 < z < 20$ ***is predicted.***

It is remarkable that, in our realistic non-singular cosmology[1],[2],[3], [4], there is an important prediction of a highest possible redshift z. From the expression $(1+z) = 1/a$, where a is the scale of cosmic expansion, we can see that a maximum value of z (highest redshift) corresponds to the minimum value of a. Let us consider the fractional contributions of mass densities that enter our Friedmann equation, where the total mass density is equal to $(3H^2/8\pi G)$, with H the Hubble constant, and G the gravitational constant. If r is the present positive value of the photonic mass density fraction, and g the present positive value of the gravitonic mass density fraction, then the mass density of matter has the positive value $(1 + r + g)$. Our Friedmann equation takes the form

$$\left(\frac{\dot{a}}{a}\right)^2 = H^2 \left\{ -\frac{r}{a^4} + \frac{(1+r+g)}{a^3} - \frac{g}{a^2} \right\} \tag{1}$$

Notice that in our scheme, both r and g *enter negatively into the equation*. Notice as well that when $a = 1$, the normalized value for the present state of the universe, the RHS of the above equation reduces to H^2. Earlier values of the expansion scale $(0 < a < 1)$ and later values $(a > 1)$ are cyclical with *turning points* corresponding to the roots of the equation

$$-r + (1+r+g)a - ga^2 = 0 \tag{2}$$

The two solutions of this equation are

$$a = \frac{1 + g + r \pm \sqrt{g^2 + 2g(1-r) + (1+r)^2}}{2g} \tag{3}$$

In our initial proposal[1], we considered the value of r that corresponds to the photon density fraction as suggested by the *microwave background* with a temperature of $T \sim 2.726$ K. Whereas the total density mass density $(3H^2/8\pi G)$ gives $\sim 5.68344 \times 10^{-27}$

kg/m^3, using the value of a Hubble fraction of 0.55 (the value which gives *our best fit with supernovae data*), and the value of the photon mass density $(\pi^2/15)(k^4T^4/\hbar^3c^5)$ gives $\sim 4.64861\times10^{-31}$ kg/m^3, we obtain $r \approx 0.0000817922$. Let us take for the graviton mass density fraction $g = 0.1$. Notice that the value of g is *always tentative* until one is able to relate it to physical measurements, or to determine the matter density very accurately. With these values of r and g, we obtain the turning points for a.

$$a_{\text{min}} = 0.0000743515 \qquad a_{\text{max}} = 11.0007 \tag{4}$$

Corresponding to a_{min}, we obtain the *highest redshift* $z \sim 13449$, and the *maximum temperature* $(2.726/a_{\text{min}}) \sim 36,664$ K. On the other hand, the *maximum matter density* is given by $(1+r+g)/a^3_{\text{min}}$ times the present value of total density. This gives 1.52113×10^{-14} kg/m^3. Notice that if the mass of a star like the sun is distributed over a certain radius to give such a mass density, the value of the radial distance would be $\sim 3.14862\times10^{14}$ m. This corresponds to ~ 2105 AU, or about 53 times the orbit of Pluto, or ~ 0.033 light year. This gives a picture of *a dense universe, at minimum contaction, full of stars, each having ample space to continue its activity undisturbed*.

The *time since minimum contraction* is obtained from the integral

$$\frac{1}{H}\int_{a_{\text{min}}}^{1} \frac{a\,\mathrm{d}a}{\sqrt{-r+(1+r+g)a-ga^2}} \approx 11.6525\,\text{Gyr} \tag{5}$$

The *time remaining before returning to contraction* is obtained from the integral

$$\frac{1}{H}\int_{1}^{a_{\text{max}}} \frac{a\,\mathrm{d}a}{\sqrt{-r+(1+r+g)a-ga^2}} \approx 962.076\,\text{Gyr} \tag{6}$$

On the other hand, we also contemplated the possibility[4] that the true photon density of the universe may be *higher* than the value suggested by the microwave background. This offers the possibility of *preserving the identity of galaxies at minimum contraction*. For instance, with a present photon temperature of ~ 16 K, we obtain a photon density of $\sim 5.51696\times10^{-28}$ kg/m^3. The corresponding photon fraction is $r \sim 0.1$. Taking $g \sim 0.1$ as well, we obtain

$$a_{\text{min}} = 0.0839202 \qquad a_{\text{max}} = 11.9161 \tag{7}$$

Correspondingly, the *highest redshift* is $z \sim 11$, the *highest temperature* is ~ 190 K, and the *highest matter density* is $\sim 1.15397\times10^{-23}$ kg/m^3. If the mass of a typical galaxy, like ours, is distributed over a certain radius to give such a mass density, the value of the radial distance would be $\sim 1.6\times10^{21}$ m. This is about 1.7 times the radius of our galaxy. This gives a picture of *a dense universe, at minimum contaction, full of galaxies, each having ample space to continue its activity undisturbed* (or possibly undergoing some mutual interactions!).

Now using the values $r = 0.1$ and $g = 0.1$, and our *advocated* value of $H = 55$ km/sec/Mega parsec, the *time since minimum contraction* is obtained from the following integral[1]

$$\frac{1}{H}\int_{a_{\min}}^{1} \frac{a\,\mathrm{d}a}{\sqrt{-r+(1+r+g)a-ga^2}} \approx 12.48\,\mathrm{Gyr} \tag{8}$$

The *time remaining before returning to contraction* is obtained from the integral

$$\frac{1}{H}\int_{1}^{a_{\max}} \frac{a\,\mathrm{d}a}{\sqrt{-r+(1+r+g)a-ga^2}} \approx 1050\,\mathrm{Gyr} \tag{9}$$

The important point that we wish to make in this paper concerns *the possible values of the maximal redshift in the cold cyclic scenario with the galaxies as the underlying protagonists*. Remarkably, the value obtained above of $z \approx 11$ does seem to be *at the edge of present day measurements*.[2] If no higher values of redshifts are measured then our choice of the photon density fraction of $r = 0.1$ that corresponds to a temperature of $T \sim 16$ would be just fine. Of course our choice of H and g are also important. However, as it would seem likely that measurements of high redshifts might well go beyond $z \approx 11$, we wish to give another compatible illustrative scenario that begins with *a lower value of temperature*—something like $T \sim 14$ K. Going *much lower than this value would disrupt the cold galactic scenario*!

The photon mass density that corresponds to $T \sim 14$ K becomes $\sim 3.23394 \times 10^{-28}$ kg/m^3. The corresponding photon fraction is $r = 0.057$. With $g = 0.1$ we obtain the following values of the expansion scale at the turning points:

$$a_{\min} \approx 0.05 \qquad a_{\max} = 11.5 \tag{10}$$

These give for the *highest redshift* $z \approx 19$, for the *maximum temperature* $T \approx 300$, and for the *maximum matter density* $\sim 5.45581 \times 10^{-23}$. The correponding radius is $\sim 9.55 \times 10^{20}$ m, which is *about equal to the radius of our galaxy*!

Notice that *the situation is very tight*! A photonic temperature higher that 16 K would get in conflict with observed redshift. A photonic temperature less than 14 K would disrupt the galactic scenario. Hence a value of redshift between $z \sim 11$ and $z \sim 20$ is predicted to be *the highest measurable redshift for distant galaxies*!

In our case, using the methods of eqs. 8 and 9, we obtain for the *time since minimum* ~ 12.1745 Gyr, and the *remaining time to reach maximum* ~ 1012 Gyr.

Further analysis pertaining to the development of our realistic nonsingular cosmology, and especially with regard to the scheme that engages the galaxies in a *cold cyclic* scenario, and which *could be tested* via the prediction of an upper bound on highest redshift (like $11 < z < 20$), will be exposed and kept uptodate at:
https://nsbcosmic.neocities.org/NSBCosmo

[1] Please note that equations 5 and 6 of our earlier paper[4] contain wrong numerical results! These come about due to faulty numerical substitution for H.

[2] You can research astrophysical websites for information regarding highest redshift!

References

[1] N.S. Baaklini, "Realistic Non-Singular Cosmology", *N.S.B. Letters*, **NSBL-RC-011**; http://www.vixra.org/abs/1312.0204

[2] N.S. Baaklini, "Realistic Non-Singular Cosmology with Negative Vacuum Density", *N.S.B. Letters*, **NSBL-RC-012**; http://www.vixra.org/abs/1401.0060

[3] N.S. Baaklini, "Realistic Decelerating Cosmology and the Return to Contraction", *N.S.B. Letters*, **NSBL-RC-014**; http://www.vixra.org/abs/1402.0002

[4] N.S. Baaklini, "Photonic Temperature & Realistic Non-Singular Cosmology", *N.S.B. Letters*, **NSBL-RC-016**; http://vixra.org/abs/1504.0007

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