Cosmological expansion in a creationist cosmology

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The redshifts of light from distant galaxies indicate expansion of the universe, and fit well with our understanding that God has stretched out the heavens. Another evidentiary result of this expansion is the adiabatic cooling of the all pervasive Cosmic Microwave Background (CMB) blackbody radiation. Starting from the Bible, it is logical to conclude that the majority of this apparent stretching, and all events more distant than about 6,000 light-years in the cosmos, occurred during Day 4 of Creation Week. From the cooling of the initial 9,000 K plasma to the currently measured 2.725 K of the CMB, it is determined that God stretched out space by a factor of 3,300. This volume cooling factor (of about 36 billion), during the creation of the heavenly bodies on Day 4, ensured the earth did not receive high levels of radiation from nearby galaxies. Thus we can see that God's plans are perfect and the heavens continue to declare the glory of God.

This paper is a continuation of a series of papers published[1–5] in an attempt to apply what is observed in the cosmos to a creationist cosmology. I suspect when King David wrote the following words, that he was uttering more about the heavens than he could possibly understand:

> 'The heavens declare the glory of God; the skies proclaim the work of his hands. Day after day they pour forth speech; night after night they display knowledge' (Ps 19:1, 2, NIV).

Many new discoveries in the past one hundred years have changed what we understand about the cosmos. These have included, most notably, that the universe is expanding. At least that is the interpretation that has been applied to the observed redshifts from distant sources.

Unique position in the universe

In order to properly interpret what we see in the night sky we need to view it with biblical glasses. Too often we don't see the forest for the trees, so to speak. We may have overlooked an obvious fact that has been well known for many decades. Edwin Hubble recognized this when he wrote in his book *The Observational Approach to Cosmology*:

> 'Such a condition would imply that we occupy *a unique position in the universe* … . But the unwelcome supposition of a favoured location must be avoided at all costs … . Such a *favoured position*, of course, is *intolerable*; moreover, it represents a discrepancy with the theory, because the theory postulates homogeneity [emphasis added].'[6]

What prompted this comment was that he was seeing galaxies *in all directions* speeding away from him by the same proportion, that is, the more distant the faster they moved. This meant we must be at the centre of the universe—but he rejected that idea on philosophical grounds. Hubble went on to say:

> 'Therefore, in order to restore homogeneity, and to escape *the horror of a unique position*, the departures from uniformity, which are introduced by the recession factors, must be compensated by the second term representing the effects of spatial curvature [emphasis added].'[7]

But there is more to it. The observations that brought him to that point were redshifts. He, and others, observed the redshift of the spectral lines in light from very distant sources. It appeared that the galaxies we see rapidly receding and their redshifts were a result of a Doppler effect, similar to that heard in the whistle of a train as it rapidly passes by. Nowadays cosmologists consider not that the galaxies are moving, but that space itself is moving (or expanding) and the galaxies are tied to (or stationary in) space.

Hubble was thus concerned that *interpreting the redshifts as recession* of the galaxies would introduce a further problem, in that the 'numbers of nebulae [galaxies] increase faster than the volume of space through which they are scattered'.[8] This new problem could only be solved *by assuming that space was curved. If curved then a centre could be avoided. There is no need for a centre or an edge to the universe, hence we are not in a unique position.*

> 'Relativity contributes the basic proposition that geometry of space is determined by the contents of space. To this principle has been added another proposition, formulated in various ways and called by various names, but equivalent, in a sense, to the statement that all observers, regardless of location, will see the same general picture of the universe. *The second principle is a sheer assumption.* It seems plausible and it appeals strongly to our sense of proportion. Nevertheless, it leads to a remarkable consequence, for it demands that, if we see the nebulae all receding from our position in space, then every other observer, no matter where he may be located, will see the nebulae all receding from his position. *However, the assumption is adopted. There must be no favoured location in the universe, no centre, no boundary; all must see the universe*

alike [emphasis added].'[9]

Hubble made many assumptions in 1937 and these assumptions still remain. They are required to avoid the obvious conclusion—that the universe is the product of special creation.

From a biblical point of view, *and within the framework of this model*,[10] we need to realize that unless light travelled faster in the past, everything we see in the cosmos, that is farther away than 6,000 light-years, is part of the creation events that occurred just over 6,000 years ago. Thus we are now viewing the creative acts of God from the beginning. It is unlikely that we can tie together a unified naturalistic cosmology to describe it all, because God's supernatural actions during creation likely suspended or superceded some of the natural laws that He planned for our universe. But we can look for mathematical descriptions that describe what we see. Those descriptions may give us further hints as to events that happened on the other side of our visual horizon. In references 11 and 12, I have attempted to do this.

Einstein's field equations

With the advent of general relativity the structure and evolution of the universe has been put into a mathematical formalism—*space-time*. Einstein himself found a static solution to his field equations, which describe the world lines, or the motion, of particles through *space-time*. He realized that the cosmos was unstable against gravitational collapse, and added a constant to his equations—the cosmological constant—to maintain the galaxies in their positions. As soon as he heard of Hubble's findings that the galaxies were receding, he is reported to have said that it had been the biggest blunder of his life.

Nowadays the Friedmann-Lemaître (FL) solutions of Einstein's field equations provide the usual basis upon which the redshifts of extra-galactic objects are understood in the standard big-bang, inflationary cosmologies. See reference 12 for mathematical detail.

The problem with that picture of the cosmos is that some galaxies have motions that defy this description. Within clusters, some galaxies have random motions, and seem to exhibit anomalously large, excess, radial (away from the observer) motions, if their redshifts are interpreted as resulting from velocity. And quasars have been shown to be associated with/ejected from parent galaxies. Therefore their measured redshifts do not place them, as is generally believed according to the Hubble Law, at very great distances near the edge of the universe.[5]

This paper is primarily concerned with the measured redshifts of the large central elliptical and the brightest spiral galaxies of a cluster. For these galaxies it has been shown, by Hubble and later Sandage, that they do indeed follow the Hubble Law.[5] Even if the distance to the galaxies is somewhat in doubt, the relationship holds for their apparent magnitude. This can be understood in terms of the redshifts of a class of galaxies. If the brightest of a cluster are used for Hubble Law determinations then they are all mostly of the same intrinsic size and the same absolute magnitude. In figure 1 the ordinate axis is the logarithmic redshift of a galaxy and the co-ordinate axis is its corrected visual magnitude. Only first ranked galaxies were chosen because of their low dispersion in absolute magnitude within the cluster. Therefore their apparent magnitude is a measure of distance, according to the inverse square law of illumination.[14]

Stretched out the heavens

But the ambiguity still remains. Are the galaxies receding from us because they are moving through space? Or are the galaxies fixed in space and is the space being, or was it, spread out, stretched or expanded, giving the illusion that the galaxies are actually moving? Experimentally and observationally there is absolutely no way to tell. Redshift,

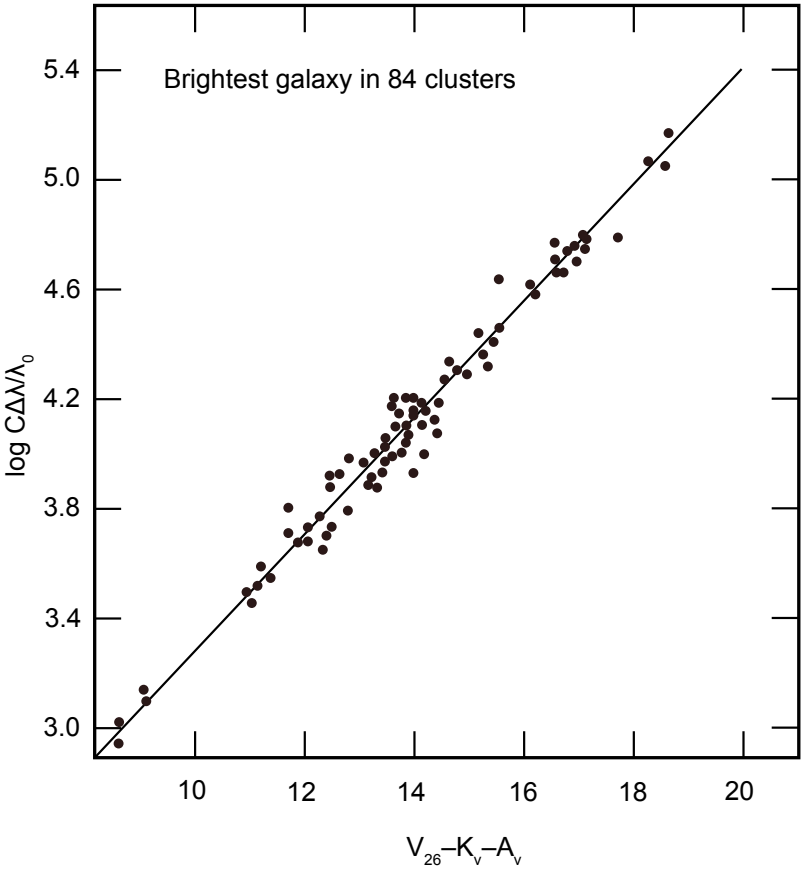


Figure 1. *Galaxy redshift as a function of visual magnitude (after figure 4 of Sandage[13]), showing that apparent magnitude is a measure of distance.*

after all, is the measurement of the relative shift in spectral lines determined from a photographic plate or a CCD[15] image.

However the Bible gives us a clue. Numerous times God says He stretched out the heavens:

> 'He wraps himself in light as with a garment; he *stretches* out the heavens *like a tent*' (Psalm 104:2).
>
> 'He sits enthroned above the circle of the earth, and its people are like grasshoppers. He *stretches* out the heavens like a canopy, and spreads them out *like a tent* to live in' (Isaiah 40:22).
>
> 'This is what God the LORD says—he who created the heavens and *stretched* them out, who spread out the earth and all that comes out of it, who gives breath to its people, and life to those who walk on it' (Isaiah 42:5).
>
> 'This is what the LORD says—your Redeemer, who formed you in the womb: I am the LORD, who has made all things, who alone *stretched* out the heavens' (Isaiah 44:24).

If we take this as the underlying mechanism for the expansion of the cosmos, then it is more probable that the space is stretched out and that God did it for a purpose. This was suggested by Russ Humphreys[16] over ten years ago.

The stretching of the heavens may have had a specific purpose in God's perfect plan: to protect the fledging earth, with its life, from all the radiation of the stars in the universe.

Creation days

Let's summarize some of the important details that occur on Creation Days 1–4 in terms of the hypotheses of this proposed model.

On Day 1, God formed the earth and matter in its immediate surroundings. The earth was formed from water. The additional matter was mostly hydrogen which was in the form of hot plasma that was placed in a region of space near Earth. I suggest that this plasma was located near to where the centre of the Milky Way Galaxy would be created on the fourth day. This plasma glowed at visible wavelengths. It provided light until God created the sun on Day 4.

On Day 2, God separated the waters. I propose this could mean placing a shell of water in the outer regions of the solar system, to protect the earth and later its inhabitants. Later on Day 4 some of this was formed into the gas giants (planets) and Trans-Neptunian objects. Much remains today as icy comets. A lot of 'water' is still out there in a halo around the solar system. This 'water' may also serve to rain down in God's judgment on the ungodly in the Day of our Lord.[2]

On Day 3, God separated the land and water-formed oceans, etc. Mostly we see only H_2O in the oceans, but when God separated the waters above and below, he also separated the elements placing a lot more hydrogen (H_2) in the waters above. It is interesting to note that models of the gas giant planets suggest that they have water ice and metallic hydrogen in their cores.[17]

On Day 4, God created the lights to rule the day (the sun) and night (the moon and planets). He also created the stars. He created the Milky Way Galaxy and other large elliptical and spiral galaxies from the hot plasma he had created on Day 1. God stretched out space,[18] by some enormous factor, and spread out the parent galaxies that He then caused to eject more galaxies as quasars in ongoing creation episodes during the course of Day 4. This is described in reference 4.

Expansion factor

The expansion of space caused adiabatic[19] cooling of space, which had plenty of time to come into equilibrium with the initial hot plasma, as God had caused an enormous time-dilation event on the earth. This meant that time flowed in the cosmos at the same rate it does on Earth now, but during the time-dilation period it was Earth's clocks that ran slow.[3] The actual factor can be estimated from the ratio of the Hubble-Carmeli time constant (τ)[20] (which is approximately the inverse of the currently measured Hubble constant) to the length of time that time-dilation continued, as determined by Earth clocks. If the latter was over Day 4 only, then the time-dilation factor (Σ) is approximately $\Sigma = \tau/(24 \text{ hours}) = 4 \times 10^{17}/(86{,}400) = 4.63 \times 10^{12}$.

The expansion factor can be calculated from the current peak of the 2.725 K CMB blackbody intensity power spectrum,[21] at about 160 GHz or 1.6×10^{11} Hz.[22] Let's assume the initial plasma was created at energies such that its blackbody intensity power spectrum peaked in visible wavelengths, or about 5.3×10^{14} Hz, which is in the yellow-colour band.[23] This provided the light of Day 1.

> 'Then God said, "Let there be light"; and there was light. And God saw the light, that *it was* good; and God divided the light from the darkness' (Genesis 1:3–4, NKJV).

Our sun has its blackbody maximum specific-intensity, or brightness, in the infrared band. This has been calculated from the Planck law[21,24] where we calculate the frequency (ω_{max}) of the radiation at the peak of the source power distribution. The power is calculated per unit area, per solid angle, per frequency interval and is temperature dependent. We then calculate the corresponding wavelength for ω_{max} to get $\lambda_{max} = 2\pi c/\omega_{max}$. The wavelength in centimetres can be determined from $\lambda_{max} = 0.5098/T$, where T is in kelvin (K).[25]

God created the sun with the intensity peak in the infrared band to provide the radiant heat needed to support life on Earth. The blackbody intensity peak of the initial plasma could have been in the same place, but I have placed it in the visible because it was only a temporary 'light' source and not needed to support life. Instead it would have been

the most intense possible light source viewed in the visible spectrum, and showed the power of God dividing the darkness with his intense light.

> 'In the beginning God created the heavens and the earth. Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters. And God said, "Let there be light," and there was light. God saw that the light was good, and he separated the light from the darkness. God called the light "day", and the darkness he called "night". And there was evening, and there was morning—the first day' (Genesis 1:1–5, NIV).

Following Humphreys, if we assume the newly formed earth was a rotating ball of water then it would have been divided into a light side and a dark side, hence the *evening* and the *morning* in Genesis 1:5.

From the above comparison we can calculate a linear expansion factor ($1+z$) where z is the expansion redshift. The ratio of the blackbody spectrum, intensity peak frequencies of the initial plasma to the intensity peak of the currently observed 2.725 K CMB give $z_{exp} = 5.3 \times 10^{14}/1.6 \times 10^{11} \approx 3{,}300$. This calculation is merely a deduction if we start the initial blackbody temperature of the first created plasma at 9,000 K.

The result is a volume expansion factor of $(1+ z_{exp})^3 = 3.6 \times 10^{10}$ increasing the volume of the universe by 36 billion times. This is the amount that space was stretched out. Conversely the density also decreased by 10 orders of magnitude, but during the expansion process new matter was continually created, so that would have tended to increase the density. The density of matter now is about 10^{-31} g cm^{-3} so at most it started at around 10^{-21} g cm^{-3}, which is about 10,000 hydrogen atoms in a cubic centimetre of space. If ionized, this would constitute plasma.

An expansion like this is definitely a major enlargement of the volume of the universe. To maintain conservation of energy, adiabatic cooling must follow. The peak intensity of the microwave power spectrum is a factor of 4×10^{10} below the peak intensity of the visible yellow power spectrum. This factor is consistent with the volume expansion factor and indicates that a real stretching of the cosmos has occurred. Given the observed CMB temperature of 2.725 K,[26] the plasma temperature would have started near 9,000 K. The temperature is calculated from the peak of the blackbody curve. This means the creation started at an expansion redshift z ~ 3300, which is now well over our present visible horizon.

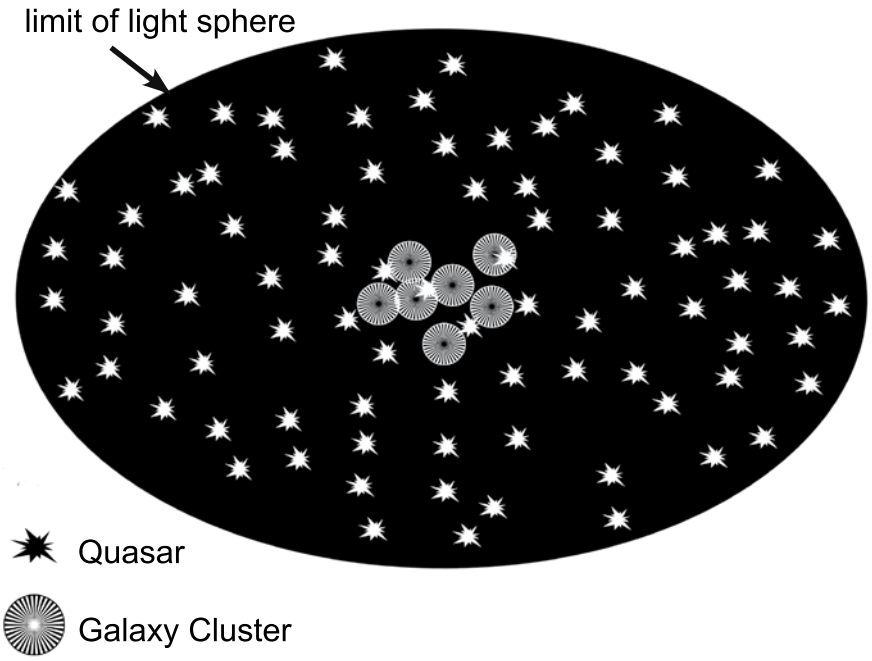


Figure 2. *A simplified schematic of the universe based on the view that the Hubble Law applies to quasars. Most of the outer sources are quasars. The limit of the light sphere is at 14 billion light-years, the presently accepted value in big bang cosmology. The universe has many more objects than these.*

Size of the universe

The observations of Arp, Burbidge and others suggest the visible universe may be not quite as large as is currently stated by the big-bang community. Certainly the structure is very different from that which big-bang astronomy would have us believe with most of the universe populated almost entirely with quasars (figure 2), which are unlikely to be so distant. I am not suggesting that no galaxies exist at high redshift, but rather that we see very few of them. This may be merely a selection effect due to extinction. Certainly the high-z type Ia supernovae teams have catalogued galaxies out to z = 1.75. In figure 2 most of the quasars are located outside the region of most of the galaxies. This is the view accepted by the dominant big-bang believing community. And this region extends out to the limit of their light sphere or about 14 billion light-years. But not all astrophysicists, cosmologists and other scientists agree with or believe this.[27] And the truth does not always belong with the majority.

If we shift those quasars to the cosmological distances of the galaxies that we often find them associated with, it radically changes our view of the universe. In figure 3 most of the quasars have been 'moved' inwards, i.e. the assumption that determined their distances has changed. According to Arp the size of the visible universe is more like 300 million light-years, out to the edge of the regions occupied by the Fornax and Virgo superclusters. Arp doesn't suggest that there are no galaxies beyond this limit, but rather that we can't see them. Keep in mind the edge

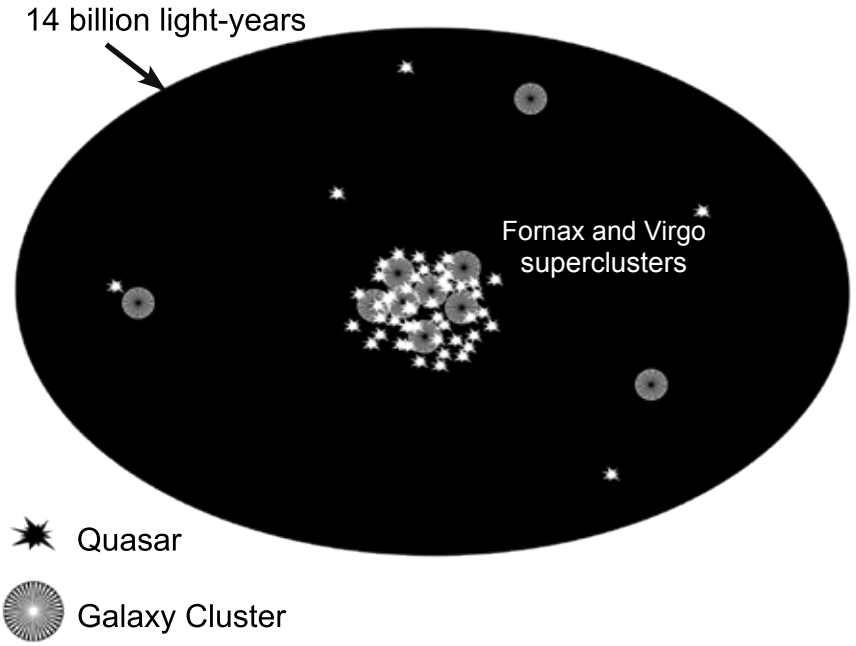


Figure 3. *A simplified schematic of the universe based on the view that the Hubble Law does not apply to quasars. This is Arp's universe and the view accepted in this creationary cosmology. The outer sources that were mostly quasars have been moved into the central region. The limit of the light sphere is of the order of 14 billion light-years, the presently accepted value in big bang cosmology.*

of the visible universe from supernovae measurement is closer to 13.7 billion light-years. So this might suggest a large expanse with very few galaxies.

In my creationist, finite-bounded universe, I suggest we actually are now seeing near to the limit of the physical universe and that there are very few galaxies beyond this. There may be some, but not many and they would have a decreasing density towards the edge. Even the large redshifts measured for some galaxies are misinterpreted due to intrinsic redshift effects. I suggest in cases like those it is merely due to the incorrect assumptions being applied within a paradigm that has no framework to consider intrinsic redshifts. That is, the very large galaxy redshifts ($z > 1$) are mostly due to an intrinsic component and not due to Hubble expansion.[28] Since these galaxies are very faint, on the edge of visibility, it is impossible to determine if they have been formed as the result of a previous ejection from another galaxy. But until we get more data at these extreme limits of detection, we can do little more than speculate.

At the beginning of Day 4, the size of the universe was much smaller. However, not all the galaxies of the present universe were created at that time. The scenario I suggest is that God started with an initial group of parent galaxies and then He spread out the heavens causing those galaxies to eject more galaxies,[29] which is a process we can still see.[4] If there were only a thousand times fewer galaxies, it still means God created about 100 million galaxies initially, at the beginning of Day 4.

Time-dilation

As proposed in reference 3, time-dilation of the universe during Day 4 of Creation Week, could have dilated the 24 hours of a single Creation Day to a period $\Sigma \approx 4.63 \times 10^{12}$ times longer in astronomical time. This means that Day 4 lasted 24 hours on Earth clocks, which is equal to 2.74×10^{-3} years $\times \Sigma = 12.7$ billion years[30,31] on astronomical clocks. Thus light from all sources had at least 13 billion astronomical years of light travel-time during Day 4.[3]

Earth clocks running a trillion times slower than astronomical clocks would mimic the effects of the earth sitting in the bottom of an incredibly deep gravitational well. This would mean that in the earth frame of reference the light from galactic sources would be shifted way up past the gamma-ray region. So it causes a blueshift $z_{TD} = \Sigma \approx 4.63 \times 10^{12}$ (subscript TD meaning time-dilation). In contrast, the stretching out of the heavens placed the galaxies at great distances introducing a maximum redshift $z_{exp} \sim 3300$ for the initial created plasma. The net effective spectrum shift z_{net} may be calculated from:

$$1 + z_{net} = \frac{1 + z_{TD}}{1 + z_{exp}}. \qquad (1)$$

In the palm of His hand

The result remains as a very large blueshift, moving frequencies to the high end of the spectrum which could be very damaging to the earth. However, as previously discussed the volume cooling ratio of 3.6×10^{10}, due to spatial expansion, reduces the intensity of the blueshifted frequencies in the rest-frame of the earth. In this case we must look at the inverse square law of illumination. The intensity of all light sources is further reduced by a factor $1/(1+z_{exp})^2$, when compared to the intensity at a reference distance, before the stretching started. This comes about because of the increase in surface area necessary for a constant amount of energy flux as space expands. Therefore during Creation Day 4, in the earth rest-frame, the relative intensity (I) after the expansion, as compared to relative intensity of the source (I_0) before the expansion, would be determined by the source redshift and the time-dilation factor. From (1) it follows that:

$$\frac{I}{I_0} \approx \frac{1 + z_{TD}}{(1 + z_{exp})^3} = \frac{4.63 \times 10^{12}}{3.6 \times 10^{10}} \approx 130, \qquad (2)$$

because $(1+z_{exp})^3$ is the volume expansion factor. Therefore, the expansion reduces the intensity increase due to time-

dilation from 10^{12} to about 130. This enormous reduction results from the stretching of the cosmos by the expansion factor that was necessary to reduce the intensity of the radiation reaching earth from the original created plasma fireball. This is the most optimistic value, as it depends at what redshift z_{exp} the galaxies were created.

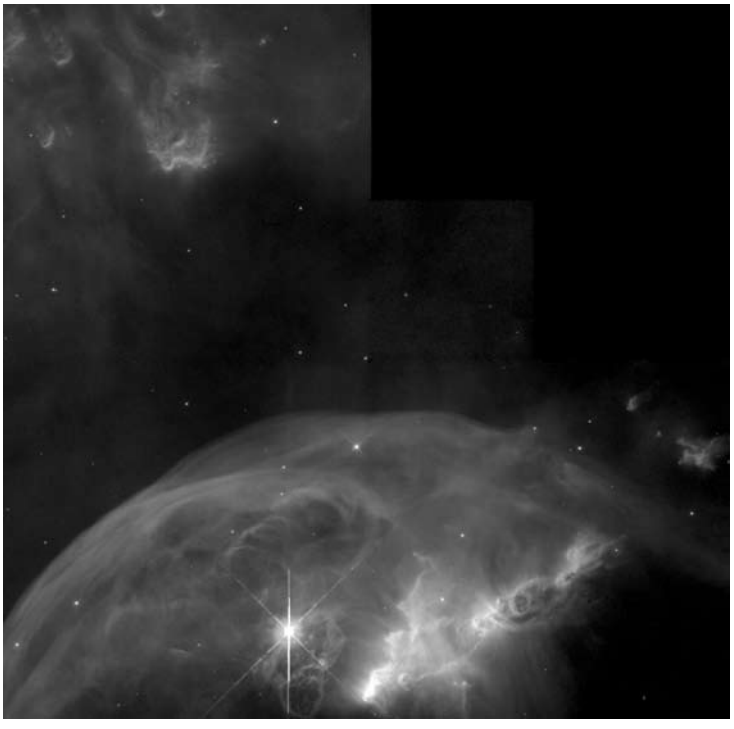
We should also consider the luminosity in the visible spectrum as defined in terms of the luminous efficiency.[25] The initial plasma fireball and all the created stars (hence galaxies) fit to the blackbody spectrum. Luminous efficiency at 9,000 K is 42 %, but at 10^{13} K it is 10^{-14} %. However all stars will have their power spectra shifted by the factor in (1) to high energies such that their luminous efficiencies become essentially zero. Effectively the cosmos becomes invisible during this period—until the end of Day 4.

Also high energy cosmic particles and photons would become ultra-high energy in the earth rest frame, depending on their distance from their source. Most would impact the stellar photon and particle fields in the galactic region. Above certain energies (~5 $\times 10^{19}$ eV) in the rest-frame of the ultra-high energy cosmic rays (particles) there is the Greisen-Zatsepin-Kuz'min (GZK) cut off.[32] Due to special relativistic effects, cosmic rays in their own rest-frame see the photon fields (which later are stretched to become the CMB) at much higher energies. Thus they should be scattered by ambient photons to pion production and never reach Earth if they travel more than 10 Mpc. This is an expected effect but it isn't fully understood as some cosmic particles of energies higher than the GZK cut-off do reach Earth. However it also true for high energy particles (above 10^{11} eV) that they would radiate energy due to braking effects called 'bremsstrahlung'[33] and inverse Compton scattering.[34]

There are also other theoretical mechanisms that could possibly decrease the level of radiation reaching the earth. These include Lorentz violating interactions between the high energy photons and virtual particles in the ZPE[35] field of the vacuum itself. Polarization of the vacuum may have occurred, creating a whole host of exotic particles that impeded the flight of these damaging rays. Some suggest that the violation of the GZK limit could be a Lorentz violation of the standard particle model of physics because their energies are very high, even approaching the Planck energy (~10^{19} GeV).

As optical photons would increase in energy to greater than 100 MeV, during Day 4, there would be a need for shielding. The Lord may have placed the 'waters above' in the intervening region of space—as a halo—around the solar system, which could provide a large shielding effect as a part of God's original design. This design would have included creating large gas giants, Jupiter and Saturn, to shield against rogue comets, etc., and a halo of frozen ices in the 'waters above' to stop cosmic rays of all types. But most importantly of all, the Lord had it all planned, providing a perfectly good creation as the earth was in 'the palm of His hand' and the 'centre of His thoughts', during His creative process.

A hypothetical observer on Earth would not have noticed the turning off of the time-dilation event, as the effect was likely placed on and around Earth only. Evidence consistent with the model should be sought to consider how great the zone of time-dilation was. However, no residual evidence would be visible in starlight; the redshift from the expansion of space would have been as we see it today, that is, if any observers soon after creation had had the tools to discover it. The cosmological, or expansion, redshifts seen today are quite small by comparison to the total redshift of the order of 3,300. However, I suggest all, or most, of the expansion occurred on Day 4 as part of God's creative acts.



NASA

Apart from a region of space around the earth, what we see in the cosmos is part of God in action on Day four.

Conclusion

From the analysis presented here, it would seem we have a universe that places our galaxy at the centre of an enormous spherically symmetric distribution with all others speeding away from us. This actually is due to God having stretched out space like a curtain with the galaxies tied to it. Humphreys has suggested that the observed redshifts we see in the starlight from large spiral galaxies, described by the Hubble Law, is the result of God having stretched out the space.

Our understanding of the form and structure of the universe is subtly biased by evolutionary thinking. It is not obvious, but nearly all events we see in the cosmos, except for a region of space 6,000 light-years

(more or less) around the earth, is part of God's actions on Day 4. With this concept we have a very different view of the universe.

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8. Hubble, ref. 6, p. 58.
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14. Astronomers must be careful in choosing the appropriate clusters. For example, according to Arp (ref. 29, pp. 153, 154) galaxy clusters in the Abell catalogue have a notoriously large scatter about the Hubble line in a redshift-magnitude plot. Arp has noted this effect in many clusters that indicate some disturbed or active character, like the Abell clusters that are strong X-ray sources.
15. Charged Coupled Device—used in modern digital imaging.
16. Humphreys, D.R., *Starlight and Time*, Master Books, Colorado Springs, CO, 1994.
17. See <www.answersingenesis.org/Home/Area/Magazines/tj/docs/v14n1_jovian.asp>, 23 May 2005.
18. Because photons would decouple from the protons of the hot plasma at about 3,000 K, it is possible that the plasma was cooled to 3,000 K before Day 4 began, by a small expansion factor of 3 or so. This would have had the effect of making the universe transparent during all of Day 4.
19. No heat flows in or out of the system.
20. Hartnett, ref. 11, pp. 76–80.
21. A blackbody (perfect radiator) emits energy per unit frequency according to the Planck equation:
$$P(\omega)d\omega = \frac{\hbar}{4\pi^2 c^2}\frac{\omega^3}{Exp(\hbar\omega/kT)-1}d\omega$$
22. See <map.gsfc.nasa.gov/m_uni/uni_101bbtest3.html>, 23 May 2005.
23. For simplicity I have assumed an isotropic source.
24. See <scienceworld.wolfram.com/physics/PlanckLaw.html>, 23 May 2005.
25. This relation is Wien's displacement law and should not be confused with its formulation for maximum specific-emission in wavelength (λ_{max} = 0.2898/T cm) [where T is in degrees kelvin] which relates more to the luminosity of the source. See <scienceworld.wolfram.com/physics/WiensDisplacementLaw.html>, 23 May 2005. From the Planck law in wavelength, a luminous efficiency can be calculated as the fraction of power in the visible wavelengths to the total power emitted over all wavelengths, and we find that our sun is 45.9% efficient at 5,800 K. At 9,000 K it would be 41.9%. The peak in luminous efficiency occurs at 6,750 K.
26. See < map.gsfc.nasa.gov/m_uni/uni_101bbtest3.html>, 23 May 2005.
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28. Remember though that a cosmological, or expansion component, is there but masked by the large intrinsic component.
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33. See <rkb.home.cern.ch/rkb/PH14pp/node16.html>, 23 May 2005.
34. Sunyaev, R.A. and Zel'dovich, Y.B., Small-scale fluctuations of relic radiation. *Astrophysics and Space Science* **7**:3–19, 1970.
35. Zero Point Energy—energy contained in the vacuum of space itself. It has been experimentally proven by experiments showing Casimir force, etc.

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