THE UNIVERSE IS MORE THAN FIVE TRILLION YEARS OLD

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Abstract: When Lorentz contraction is included in travel time estimates, the Universe is found to be much older than presently believed.

With the 'flat universe' assumption and the Cosmological Principle, we can construct a sparsely populated model 'universe' which behaves similarly to our actual Universe. This 'universe' consists of a Cartesian grid of hydrogen atoms spaced at an arbitrarily large distance, e.g. one trillion light-years on a side. These atoms' mutual gravitational attraction is so low that they can be held stationary. The remainder of this 'universe' is empty, having no other net energy density ε from photons, neutrinos, or any other form of equivalent rest mass. 'Vacuum energy' density is held at zero.

We occupy some sort of life-sustaining vessel within this 'universe', and add a light-emitting source, e.g. a star, at some large distance. This star can be either at fixed distance, or can be moving away from us at a radial speed v.

If the star isn't moving away from us, the observed travel time t_{obs} upon our reception of its light is simply given:

$$t_{obs} = t_\lambda = \frac{r}{c} \tag{1}$$

Where r is the proper distance, and c is the speed of light. According to Einstein, the speed of light doesn't change, so light's travel time t_λ upon emission doesn't change for any one r, regardless of how fast the star is moving away.

In our reference frame, if the star *is* moving away from us, the observed travel time t_{obs} upon our reception of its light *does* change, by the Lorentz factor $\gamma = 1/\sqrt{1 - v^2/c^2}$:

$$t_{obs} = \gamma t_\lambda = \frac{r}{c\sqrt{1-\frac{v^2}{c^2}}} = \frac{r}{c\sqrt{1-\beta^2}} \tag{2}$$

Where $\beta = v/c$. Time dilation γ in such a model 'universe' is independent of the proper distance r at the time of emission, and only depends on the recession rate v. This concept applies to the actual Universe in which we live. In our Universe, however, time dilation is distance-dependent, due to Hubble flow. The light source's recession rate $v_{z'}$ is connected to the cosmic redshift z:

$$z' = z + 1 = \sqrt{\frac{1+\frac{v_{z'}}{c}}{1-\frac{v_{z'}}{c}}} = \sqrt{\frac{1+\beta_{z'}}{1-\beta_{z'}}} \qquad (3)$$

The function $v_{z'}$ vs. z' isn't readily found by this author at least, so instead we solve Eq. (3) for z' by numeric convergence of $\beta_{z'}$. We can then connect γ with the z' domain by inserting $\beta_{z'}$ into Eq. (2).

For $z > 10$, γ vs. z' approaches linearity:

$$\gamma_{z'} = \frac{z'}{2} \qquad (4)$$

For $z \leq 10$, the author found an adequate analytic approximation for $\gamma_{z'}$ as a third-order ln-ln polynomial. We will nonetheless use Eqs. (2) and (3), as they give better precision. Some relevant values of $\gamma_{z'}$ are given in Table 1.

Table 1. Lorentz factor γ vs. cosmic redshift z.

Cosmic redshift z	Lorentz factor γ	$\gamma/(z+1)$
0.1	1.0045	0.913
0.5	1.083	0.722
1	1.250	0.625
2	1.667	0.555
3	2.125	0.531
4	2.600	0.520
5	3.083	0.514
6	3.571	0.510
7	4.062	0.508
8	4.556	0.506
9	5.050	0.505
10	5.546	0.504
11	6.042	0.503
12	6.540	0.503
13	7.036	0.503
14	7.533	0.502
15	8.031	0.502

The Lorentz factor γ is a special effect. This means that lookback $(t_0 - t) = t_{obs}$ is the same if source and observer switch places. Lorentz-adjusted lookback thus constitutes elapsed cosmic time since emission. For example, any luminous objects we see at $z = 9$ are older than the photon travel time by a factor of five. At the epoch of last scattering, $z = 1089$, so from Eq. (4), the Universe was older by a factor of 545. Current estimates of Universal age at last scatter are around ten billion years. Lorentz contraction indicates that the last-scatter Universe was actually much older: 5.45 trillion years ago.