Original version: 2019-07-26, last edited: 2020-08-29

Please also read my main treatise: http://henk-reints.nl/astro/HR-on-the-universe.php
as well as my other documents at http://henk-reints.nl/UQ/index.html

The big bang and the *age* of the universe

An important aspect of Special Relativity is that both observers are equally right, each from their own perspective. And both observe the same *redshift* when looking at each other, yielding their mutual relative *velocity*, and based on one another's *magnitude* or observed cepheids or so, they can derive their mutual *distance*. From the symmetry of this scenario follows they must agree on both this *velocity* and *distance*. Then they simply calculate how long ago - each in their own local *time* frame - their mutual *distance* equalled zero as:

$$t_H = \frac{r}{v_H}$$

where v_H is their relative *velocity* in the *Hubble flow*, which is to be assumed constant over *time* because of Newton's 1st law, r is their mutual *distance*, and the resulting t_H is the *Hubble time*, which grows at the "*speed of time*". It is obvious that both derive the very same *Hubble time*, in accordance with the Cosmological Principle which says the universe has roughly the same look and feel everywhere, in agreement with all observations (and common sense). Edwin Hubble discovered that every distant object has an r and v_H yielding the very same *Hubble time*, which implies all of them where right here at the very same moment, an event called the big bang. This means the *Hubble time* manifests as the *age* of the entire universe, whereupon all observers agree, wherever they reside.

From now on, when I say *age* in general, or any specific object's *age*, I mean the *age* of the universe, as seen from the object under consideration in its own local *time* frame, i.e. the amount of *time* elapsed since the big bang as seen from over there, as if every observed object came into being at that event.

Regarding distant objects the above implies that both their (they're there) and our (we're here, hear?) clocks are synchronised in such a way that each of them shows the same current *Hubble time*. For this synchronisation, any *light travel time* should not be taken into account. It is without any delay, as if the distant object is just right here at this very moment, but at its own *Hubble velocity*. Its current proper *age* equals our current proper *age*, being the *Hubbe time*. Please note that "equal" does not mean "the same". Both *ages* are in one's own local *time*, but they have the same value.

Einstein discovered *time dilation*, which is due to *velocity* only and not *distance*. Of course it also applies to a distant object's entire *Hubble time*, due to its *Hubble velocity* with respect to us. In our local *time* it then becomes a far longer *time span*, going back to way before the big bang. Yes, that is what happened before the big bang: all other objects already escaped from it, as observed in our *time* frame. And as seen from over there it is just the other way round. Do you see the twin paradox looming? They left here before we departed there, and we left there before they departed here. Yes!

It means that, as observed from its own perspective in its own local frame, every object was launched out of the big bang as the very last item. The entire universe already existed, except the object itself. That's what happened before the big bang, as seen from everywhere. As seen from here, the Οδός μπύρας[1] galaxy already existed, and as seen from there, our Milky Way already existed.

apprehension ≠ comprehension

And the more distant an object is, the greater its *Lorentz factor* will be. *Time dilation* then stretches its *Hubble time* as observed by us towards negative infinity. So now we know what existed before the big bang: everything, except ourselves.

[1] Οδός μπύρας = Odós býras = Beer street

But there is a flaw in the above. As said, both observers agree on their mutual *velocity* as well as their *distance*. But that was valid at every moment in *time* they ever called now.

An essential aspect of Einstein's relativity is that every observation is to be regarded from each observer's own perspective. Whenever he does an observation, he calls that point in *time* now. His now is attached to him and he himself is fixed to the origin of his local frame. Then his now is also fixed to this origin. And for him the laws of nature apply from his own perspective. All *time* he experiences is always relative to his now moment, just like all *distances* he observes are relative to himself at this origin.

The essence is that now is the only meaningful temporal reference point and all calculations should be done with respect to now.

> Sed fortasse proprie diceretur: tempora sunt tria, praesens de praeteritis, praesens de praesentibus, praesens de futuris. Sunt enim haec in anima tria quaedam, et alibi ea non video praesens de praeteritis memoria, praesens de praesentibus contuitus, praesens de futuris expectatio.
> *But perhaps it might be said rightly that there are three times: what is current of the past, what is current of the present, and what is current of the future. After all, these three exist somehow in the soul, I do not see them elsewhere: present memory of the past, present observation of the now, present expectation of the future.*
> Aurelius Augustinus Hipponensis, 354-430CE, Confessiones 11.20.

Let's call the observers: *Here* and *Yonder*. Their mutual *Lorentz factor* in the Hubble flow is γ_H. At the moment they both call now in their own frame, their *ages* are a_H and a_Y and from the above follows:

$$a_H = a_Y$$

Time dilation causes *Yonder*'s big bang moment to have occurred in *Here*'s local *time* frame at:

$$t_{bb,Y} = a_H - \gamma_H a_Y$$

hence:

$$t_{bb,Y} = a_H - \gamma_H a_H$$
$$= a_H(1 - \gamma_H) < 0$$

in *Here*'s *time*, so as *Here*'s *time* progresses, *Yonder*'s big bang moment goes backwards in time at γ_H times the "*speed of time*" relative to *Here*'s now moment. Of course the same is true the other way round.

At *Here*'s big bang moment however, we've got $a_H = 0$, and then $t_{bb,Y} = 0 \cdot (1 - \gamma_H) = 0$, so contrary to the above, both big bang moments must have coincided! Above we found that, as seen by *Here*, *Yonder*'s big bang happened first and as seen by *Yonder*, *Here*'s big bang happened first, but when it actually took place it must have been a single event, so it remains meaningless to ask what happened before it. But as seen in any local *time* frame, when looking back to the big bang everything else escaped from it before the observer himself. He was the very last one.

As seen from *Here*, *Yonder*'s timeline is stretched by the *Lorentz factor* in both directions with respect to their respective nows, where they are of the very same *age*, i.e. the *Hubble time*. *Yonder*'s past is stretched in *Here*'s past, and similarly *Yonder*'s future is stretched in *Here*'s future. Then *Here* sees *Yonder*'s last clock tick to be deeper in history than what *Yonder* sees itself. In fact, one should not consider clock *rates*, but tick *intervals*. A moving clock is not ticking slower by the *Lorentz factor*, but the *that-long-ago* - which always is with respect to now - of each tick is multiplied by it. This apparently yields a lower clock *rate*, but have you ever observed an event occurring in the past or did you call it now as it took place? One cannot observe past clock ticks, so this lower *rate* is merely a retrospective illusion. Both nows must perpetually coincide since both observers call it now when they observe one and the same event. This must also apply to each and every clock tick as it occurs.

This perfectly suits the well-known muon experiment, which was the first confirmation of Special Relativity. At the moment of observation of the muons at ground level, their genesis is deeper in the observer's past than in the muon's own past, so they seem to have existed longer than they should. The paradox does not exist now, but it retrospectively appears in the past.

Twin paradox

All of the above gives a new vision on the twin paradox. As should now be obvious from the above, both must continuously have the very same *age* and for each of the twins his sibling's birth is regressing into his own pre-birth *time*, although their common incarnation was one single event (assuming identical twins). The stationary one retrospectively sees his sibling to be born earlier whilst he knows it actually occurred simultaneously, cf. the aforementioned big bang story.

In the future it would be similar, causing a now observed moving clock to have apparently ticked faster that what was expected on beforehand.

A distant object's proper *age*

Let's have a look at how the *light travel time* has its effect on how Here and Yonder observe one another. We will do it dimensionless, as a fraction of c, the *speed of light*, as well as of the *Hubble time* and *distance*.

Equation [66] on page 12 of my main treatise http://henk-reints.nl/astro/HR-on-the-universe.php gives the dimensionless *age* of an observed object in its own time frame. I derived it as follows.
The dimensionless *Hubble velocity* is:

$$\beta_H = \frac{v_H}{c}$$

The correct equation for the *lookback time* (according to the corrected form of the Hubble-Lemaître law, eq. [53] in the main treatise, see also http://henk-reints.nl/astro/HR-correct-Hubble-Lemaitre-law.pdf) equals:

$$\tau_L = \frac{\beta_H}{1+\beta_H}$$

Yes, this is the only correct formula for the *lookback time* to any object at a given *Hubble velocity*. It was derived without fabricating anything. As explained, τ_L should be multiplied by the *Hubble time* in order to obtain a "normal" *time*.

The moment of emission of a now observed photon then equals now minus this *lookback time*:

$$\tau_e = 1 - \tau_L = 1 - \frac{\beta_H}{1+\beta_H} = \frac{1}{1+\beta_H}$$

This τ_e is in <u>our</u> local *time* frame and it tells when the light we now observe was emitted. In order to find <u>its</u> proper *age* in <u>its</u> local *time* it must be divided by the *Lorentz factor* since <u>we</u> see <u>its</u> *time* go slower, <u>its</u> clock did fewer ticks, it's what <u>we</u> read on <u>its</u> clock. I name it *inverse time dilation*.

Please realise that in the Global Positioning System the satellites' clocks have been adjusted by applying the very same *inverse time dilation*. The accuracy of GPS ($\Delta <$ 7.80 m in 95% of the - open field - measurements) confirms that division by the *Lorentz factor* yields correct results.

To avoid the perpetual need of using $z+1$ everywhere, I use $\zeta \equiv z+1$, which is called the *Doppler factor*:

$$\tau_e' = \frac{\tau_e}{\gamma_H} = \frac{1}{1+\beta_H} \Big/ \frac{1}{\sqrt{1-\beta_H^2}} = \frac{\sqrt{1-\beta_H^2}}{1+\beta_H} = \frac{\sqrt{(1-\beta_H)(1+\beta_H)}}{1+\beta_H} = \sqrt{\frac{1-\beta_H}{1+\beta_H}} = \frac{1}{\zeta} = \frac{1}{z+1}$$

which is equation [66] in http://henk-reints.nl/astro/HR-on-the-universe.php.

<u>It is however incorrect!</u>

Although it may look like a *time span* (since the big bang), τ_e obviously is a point in *time* and then it is wrong to apply the *Lorentz factor*. *Time dilation* influences *time spans* and not points in *time*. We should not simply subtract from <u>our</u> now the *light travel time* as observed (derived?) by <u>us</u> to find <u>its</u> proper *age*.

As explained, now is the only meaningful temporal reference point, so these *time spans* should always be regarded with respect to each proper now, so in order to find its *age* in <u>its</u> frame when it emitted the light we

now observe (in our frame), we must subtract the corresponding *time* elapsed since this emission in its frame from its now. We must read its clock as seen by itself. Therefore we must apply *inverse time dilation* to the *lookback time* as observed by us in our frame, yielding how long ago in its *time* the emission took place:

$$\Delta\boldsymbol{\tau}'_{\boldsymbol{E}} = \frac{\tau_L}{\gamma_H} = \frac{\beta_H}{1+\beta_H}\Big/\frac{1}{\sqrt{1-\beta_H^2}} = \frac{\beta_H\cdot\sqrt{1-\beta_H^2}}{1+\beta_H} = \frac{\beta_H\cdot\sqrt{(1+\beta_H)(1-\beta_H)}}{1+\beta_H} = \boldsymbol{\beta_H}\cdot\sqrt{\frac{\boldsymbol{1-\beta_H}}{\boldsymbol{1+\beta_H}}} = \frac{\beta_H}{\zeta}$$

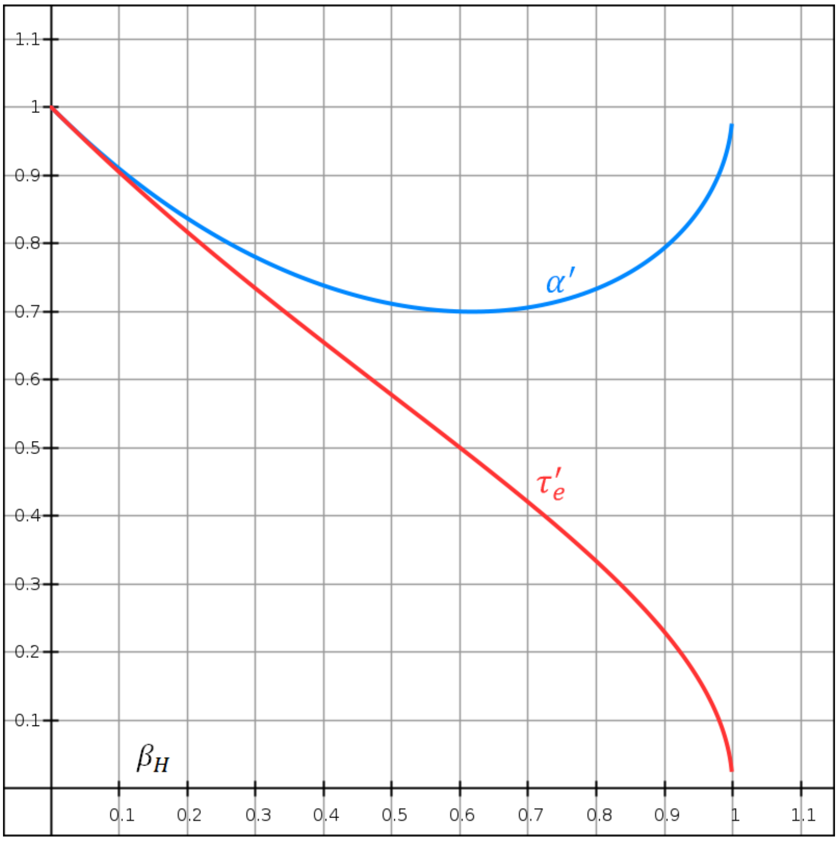
$$= \frac{\zeta^2-1}{\zeta^2+1}\cdot\frac{1}{\zeta} = \frac{\boldsymbol{\zeta^2-1}}{\boldsymbol{\zeta^3+\zeta}} = \frac{(z+1)^2-1}{(z+1)^3+z+1} = \frac{z^2+2z}{(z^3+3z^2+3z+1)+z+1} = \frac{\boldsymbol{z^2+2z}}{\boldsymbol{z^3+3z^2+4z+2}}$$

So this $\Delta\tau'_E$ is the *time elapsed* since emission as measured in its *time*, whilst τ'_e was the wrongly presumed point in its *time* when this emission would have occurred.

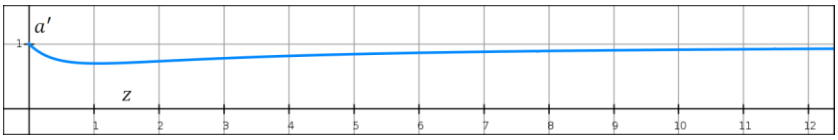
For both it and us the same *Hubble time* applies, which in its dimensionless form of course equals 1. We then obtain the object's dimensionless proper *age* in its local *time* as:

$$\begin{aligned}
\alpha' &= 1-\Delta\tau'_E \\
&= 1-\beta_H\cdot\sqrt{\frac{1-\beta_H}{1+\beta_H}} \\
&= 1-\frac{\zeta^2-1}{\zeta^3+\zeta} = 1+\frac{1-\zeta^2}{\zeta^3+\zeta} = \frac{\zeta^3-\zeta^2+\zeta+1}{\zeta^3+\zeta} \\
&= 1-\frac{z^2+2z}{z^3+3z^2+4z+2} = \frac{(z^3+3z^2+4z+2)-(z^2+2z)}{z^3+3z^2+4z+2} = \frac{z^3+2z^2+2z+2}{z^3+3z^2+4z+2}
\end{aligned}$$

This α' now replaces τ'_e and it is a distant object's proper *age* (since the BB) in its local *time* when it emitted the photon we observe right now, i.e. we see the distant object how it was when it had this *age* in its own proper *time*. It is the blue curve in next image. The red curve is the wrong one, i.e. the cited equation [66].



An object's dimensionless proper age in its local time as observed by us today,
as a function of its dimensionless Hubble velocity, red = wrong = eq. [66], blue = correct



An object's dimensionless proper age (a' should be α') in <u>*its*</u> *local time as observed by* <u>*us*</u> *today, as a function of its redshift*

Please note both graphs show a minimum in the blue curve, for which we find:

$$\alpha'_{min} = 1 - \sqrt{\frac{5\sqrt{5}-11}{2}} \approx 0.6997 \quad @\, \beta_H = \frac{\sqrt{5}-1}{2} = \frac{1}{golden\ ratio} \approx 0.6180 \ \triangleq\ z = 1.0582$$

As derived in my main treatise (eq. [61]), we cannot ever look back further than half the *Hubble time*. Older light already passed us, we've missed it. We must of course apply *inverse time dilation* to this maximum *lookback time* too and then subtract it from the *Hubble time* to obtain the object's proper *age* when it emitted that light.

Doppler effect

Now suppose the light source travelling away from us at its *Hubble velocity* is emitting coherent light. Then its emitted wave periods are its clock ticks which we can observe and count, thus reading that clock. But doesn't the *relativistic Doppler effect* apply to that light? Doesn't this mean the *Doppler factor* $\zeta_H = \sqrt{\frac{1+\beta_H}{1-\beta_H}}$ should be used for *longitudinal time dilation*, instead of the *Lorentz factor*? Let's see what it yields. We'll leave out the H-suffix:

We find: $\Delta\tau'_E = \frac{\tau_L}{\zeta} = \frac{\beta}{1+\beta} \cdot \frac{1}{\zeta} = \frac{\beta}{1+\beta} \cdot \sqrt{\frac{1-\beta}{1+\beta}}$

Above, using the *Lorentz factor*, we found: $\Delta\tau'_E = \beta \cdot \sqrt{\frac{1-\beta}{1+\beta}}$

and using: $\beta = \frac{\zeta^2-1}{\zeta^2+1}$

we derive: $\Delta\tau'_E = \frac{\frac{\zeta^2-1}{\zeta^2+1}}{1+\frac{\zeta^2-1}{\zeta^2+1}} \cdot \frac{1}{\zeta} = \frac{\zeta^2-1}{(\zeta^2+1)\left(1+\frac{\zeta^2-1}{\zeta^2+1}\right)} \cdot \frac{1}{\zeta} = \frac{\zeta^2-1}{\zeta^2+1+\zeta^2-1} \cdot \frac{1}{\zeta} = \frac{\zeta^2-1}{2\zeta^3}$

rendering: $\alpha' = 1 - \tau'_E = 1 - \frac{\zeta^2-1}{2\zeta^3} = 1 - \frac{1}{2}\left(\frac{1}{\zeta} - \frac{1}{\zeta^3}\right)$

Above, using the *Lorentz factor*, we found: $\alpha' = 1 - \tau'_E = 1 - \frac{\zeta^2-1}{\zeta^3+\zeta}$

We can rewrite the Doppler version as: $\alpha' = 1 - \frac{1}{2}\left(\sqrt{\frac{1-\beta}{1+\beta}} - \sqrt{\frac{1-\beta}{1+\beta}}^{\,3}\right) = 1 - \frac{\beta}{1+\beta} \cdot \sqrt{\frac{1-\beta}{1+\beta}}$

or: $\alpha' = 1 - \frac{1}{2}\left(\frac{1}{z+1} - \frac{1}{(z+1)^3}\right)$

which yields the images below.

We also find: $\frac{d\alpha'}{d\beta} = \frac{2\beta-1}{\sqrt{\frac{1-\beta}{1+\beta}} \cdot (1+\beta)^3}$

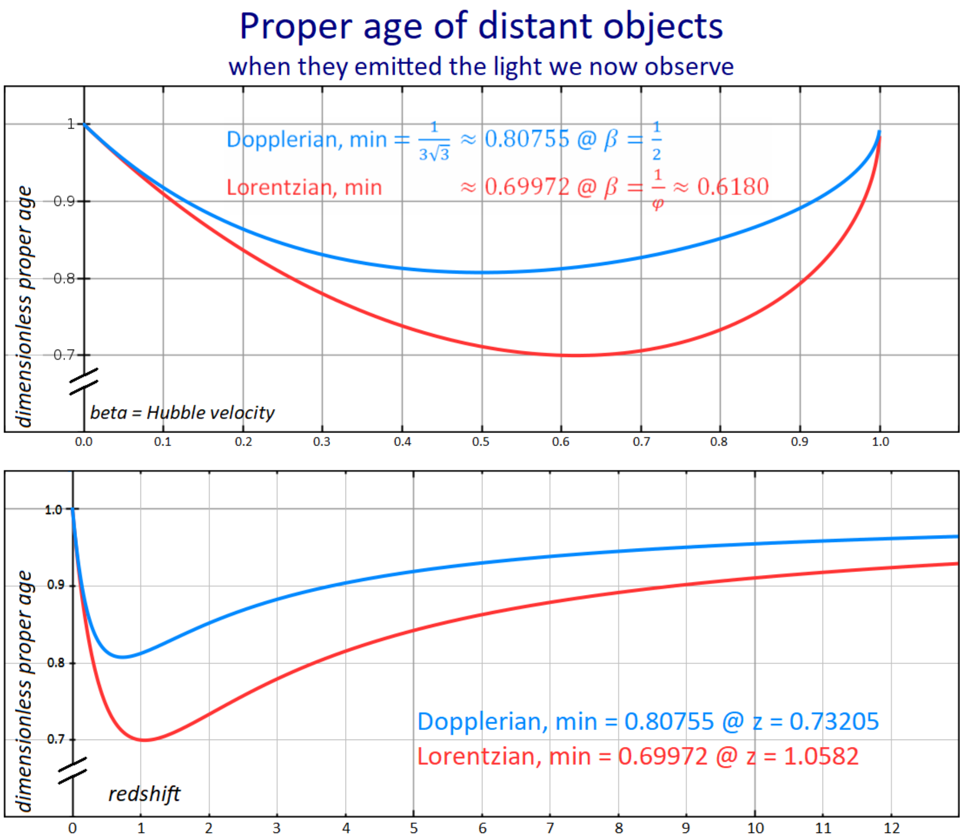
yielding: $\frac{d\alpha'}{d\beta} = -1 \text{ if } \beta = 0$

which is logical, since for nearby objects the *lookback time* must of course be proportional to the *distance*.

But once *time dilation* has come out of Pandora's box, things will become weirder and weirder. Please be honest, do you <u>really</u> understand the constancy of the *speed of light*? In fact, even Einstein just took it for granted, as he wrote:

> Wir setzen noch der Erfahrung gemäß fest, daß die Lichtgeschwindigkeit im leeren Raume eine Universelle Konstante sei.
> *We yet ascertain based on experience, that the velocity of light in empty space be a universal constant.*

He didn't mention that he too could not really get to the bottom of it, but he just derived its consequences and we have to accept this weirdness as a truth derived from facts.



Lorentzian: $\alpha'_L = 1 - \beta \cdot \sqrt{\frac{1-\beta}{1+\beta}} = 1 - \frac{\zeta^2-1}{\zeta^3+\zeta} = \frac{z^3+2z^2+2z+2}{z^3+3z^2+4z+2}$

Dopplerian: $\alpha'_D = 1 - \frac{\beta}{1+\beta} \cdot \sqrt{\frac{1-\beta}{1+\beta}} = 1 - \frac{\zeta^2-1}{2\zeta^3} = 1 - \frac{1}{2}\left(\frac{1}{z+1} - \frac{1}{(z+1)^3}\right)$

$\alpha'_{D,min} = \frac{1}{3\sqrt{3}} \approx 0.808$ at $\beta = \frac{1}{2}$, $z = \sqrt{3} - 1 \approx 0.732$

CONCLUSION:

We cannot and do not look back very far in *time* in a distant object's proper frame.
The proper *age* of distant objects is at least ~81% of the *Hubble time*.

Older light already passed us, we've missed it and we'll never get another opportunity to observe it.

In his original publication, Einstein wrote:

Für Überlichtgeschwindigkeiten werden unsere Überlegungen sinnlos; wir werden übrigens in den folgenden Betrachtungen finden, daß die Lichtgeschwindigkeit in unserer Theorie physikalisch die Rolle der unendlich großen Geschwindigkeiten spielt.
For superluminal velocities our contemplations become senseless; moreover, in the following considerations we will find that the speed of light physically plays the role of the infinitely large velocities.

And indeed, the apparent *light travel time* when both *time* frames are considered appears to be far less than what would be expected at the *speed of light* over the given distance. One should in this regard not ponder the light itself, but only *time* in each frame. According to Einstein's second postulate the relative *velocity* of a light source is irrelevant. The *speed of light* is a meaningless concept as far as the light source is concerned, it just needed to get rid of the *energy* and that's it. The *speed of light* applies to the observer only, who invariably perceives c. But when comparing *ages* it looks as if the light travels way faster, trying to hide differences by mimicking infinity, in which it asymptotically succeeds for very distant objects.

Effective *speed of light*

Equations [53] and [54] in http://henk-reints.nl/astro/HR-on-the-universe.php give an object's not fantasised but correctly derived

light travel distance: $\rho_L = \frac{\beta_H}{1+\beta_H}$

and dimensionless *current proper distance* as: $\rho_p = \beta_H$ and not even a *Planck length* more.

From these we can easily derive two versions of the apparent dimensionless "effective *speed of light*" (or "emitted *speed of light*"). We define $\Delta\alpha$ as the observer's proper *age* at his proper moment of observation minus the light source's proper *age* at its proper moment of emission, which is not to be considered a true *time span*. Nevertheless, because their now continuously equals the *Hubble time* just like our now does, it equals the *time* elapsed in the distant frame since it emitted the light. For $\Delta\tau'_E$ we'll use the Dopplerian version which of course is the correct one to use.

Based on the *current proper distance* we find:

$$c_{e,p} = \frac{\rho_P}{\Delta\alpha} = \frac{\rho_P}{\Delta\tau'_E} = \frac{\beta}{\frac{\beta}{1+\beta}\cdot\sqrt{\frac{1-\beta}{1+\beta}}} = (1+\beta)\sqrt{\frac{1+\beta}{1-\beta}} = (1+\beta)\zeta = 2\zeta\frac{\zeta^2}{\zeta^2+1} = 2(z+1)\frac{(z+1)^2}{(z+1)^2+1}$$

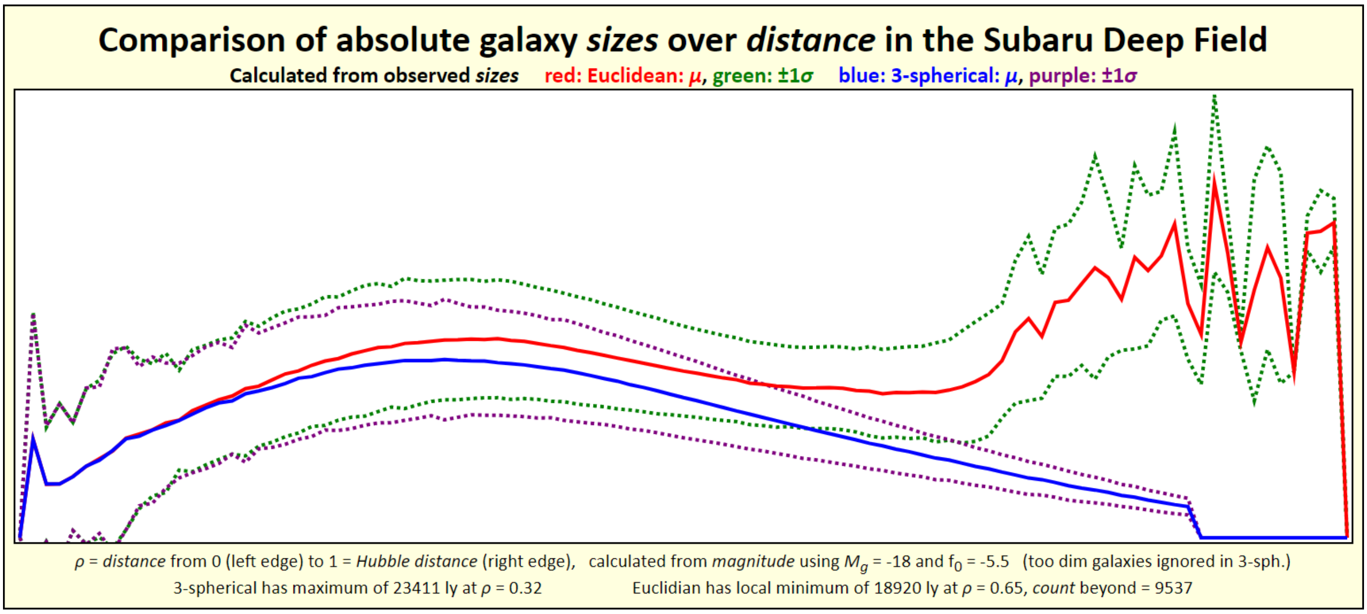
$$\lim_{\zeta\to\infty} c_{e,p} = 2\zeta = 2(z+1)$$

and based on the *light travel distance* we obtain:

$$c_{e,L} = \frac{\rho_L}{\Delta\alpha} = \frac{\rho_L}{\Delta\tau'_E} = \frac{\frac{\beta}{1+\beta}}{\frac{\beta}{1+\beta}\cdot\sqrt{\frac{1-\beta}{1+\beta}}} = \sqrt{\frac{1+\beta}{1-\beta}} = \zeta = z+1$$

Sizes of distant galaxies

Now please consider figure 8 on page 6 of http://henk-reints.nl/astro/HR-Geometry-of-the-Universe-v2b-20190729T0603Z.pdf, which shows the diameters of distant objects in the Subaru Deep Field. One should examine the blue line, which was calculated using 3-spherical geometry of the universe, as described in that document.



The decline towards the left is due to the fact that the Subaru Deep Field is not aselect, it was chosen to contain as few as possible known nearby objects. Farther away, all galaxies appear to have been linearly growing since the big bang, and one usually presumes this *growth* is caused by galaxies feasting on smaller ones over *time*. But the above says that at the moment of emission of the light of those distant objects, the universe as observed over there already was nearly as old as how we observe it right here and now, so this apparent *diameter growth* cannot be due to such a feast. But would it not be true that the expansion of the universe must be just as int<u>ra</u>galactic as it is int<u>er</u>galactic? Edwin Hubble discovered longitudinal expansion of the universe, i.e. in the line of sight, and the above image reveals its transverse equivalent, which seems perfectly linear (in a 3-spherical geometry of the universe).

Cosmic Microwave Background

For $\beta_H \to 1$ (or $z \to \infty$) we arrive at the entity that emitted (this past tense is in <u>our</u> proper *time*) the CMB, whatever it may have been. The above implies that, in its own proper *time*, for this CMB source the *age* of the universe already very closely approached the *Hubble time* at the very moment it emitted the CMB we observe right now. But isn't the CMB supposed to have been emitted at or just after the moment of the big bang itself? Well, that moment is in <u>our</u> proper *time*, not <u>its</u>. Why wouldn't the CMB emission have lasted the entire *Hubble time* in its own frame? Or might it be that the big bang is just another illusion by misinterpretation of phenomena, just like a magician fools us by actually doing something else? After all, we did not observe the big bang, we only derived it.

Philosophising

A photon is emitted by the CMB source at a moment <u>it</u> calls "now" in <u>its</u> local *time*. I'll call it now_{CMB}. We receive that photon at a moment <u>we</u> call "now" in <u>our</u> local *time*. I'll call it now_{obs}. From the above we cannot conclude anything else than that both $now_{CMB} = t_H$ and $now_{obs} = t_H$, which implies $now_{CMB} = now_{obs}$. Please keep in mind both nows are in different *time* frames, so although they are equal they are definitely not the same.

An interesting aspect of Special Relativity is that *time dilation* and *Lorentz contraction* at the very *speed of light* cause a photon to experience zero *travel distance* during *zero time*, as seen from its own perspective. Doesn't the above approach this zero *travel time* as perceived by the photon, reaching for $c = \infty$?

It is plausible that the objects in space are inert and according to Newton's 1st law their *velocities* should then be constant. But did we <u>observe</u> they actually are? What we do observe is a *velocity* proportional to the *distance* and isn't *velocity* the derivative of *distance*? What comes out if a derivative is proportional to the function? Yes, $d = e^t$. Its tangent at $t = w$ ("whenever") is given by: $d = e^w(t + 1 - w)$ and it has its root at $t = w - 1$, so the apparent lookback to zero always equals -1, but $d(w - 1) \neq 0$. <u>**IF**</u> the expansion of the universe would indeed be exponential it would still look the same at any moment, including now, and a linear lookback would perpetually show the very same *age*, so the *Hubble time* would never change. Then the *Hubble distance*, for which we have: $d_H = c \cdot t_H$ must be an apparent constant as well.

What exactly is *distance*? Truly empty space has no reference points at all, and without those, *distance* is a meaningless concept. It becomes only significant if it can be measured, like for example by triangulation. But then you must already know the base of the triangle. This applies similarly to every method of *distance* measurement. We <u>must</u> have a primordial ruler. This primordial *distance* measurement can only be done by counting $things$.

> *Distance* is the minimal number of identical undeformable $things$ that are needed to establish a contiguous connection between two other $things$.

And these counted $things$ essentially are the atoms that build up a ruler, so the whole concept of *distance* depends on the *size* of atoms.

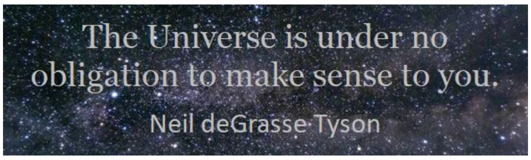
But the S.I. unit of *length*, the metre, is defined as the *distance* light travels in $1/299\,792\,458$ second, which implicitly defines the *speed of light*. With this definition of the unit of *distance* we do not have any count of $things$ whatsoever and we actually measure *light travel time* instead of true *distance*. However, the *speed of light* was once measured using the original definition of the metre, being a ten millionth of the *distance* from the North Pole to the Equator along the meridian of the Pantheon in Paris (actually measured from the belfry in Dunkirk via Rodez Cathedral to the fortress of Montjuïc in Barcelona). The *speed of light* has just been rounded to and fixed at $c = 299\,792\,458$ m/s to be used in the new definition of the metre, but this value obviously originates from the number of atoms that build up the earth, i.e. *things*.

As already mentioned, figure 8 on page 6 of http://henk-reints.nl/astro/HR-Geometry-of-the-Universe-v2b-20190729T0603Z.pdf shows the *diameters* of distant galaxies linearly decrease with the *distance*, and since they are NOT very young galaxies that have not yet accumulated matter by merging with others or so, this can only be due to the expansion of the universe, i.e. the expansion of empty space, which apparently is just as int*ra*galactic (i.e. int*er*stellar) as it is int*er*galactic, as said. But why would/could it not be int*ra*stellar as well, which is the same as int*er*atomic? And what about int*ra*-atomic...?

The latter would yield an expanding primordial ruler, and we would/might in no way be able to experience or detect that, since everything we can use as a reference will expand with it (with the current definition of the metre it certainly is undetectable since it measures *light travel time*, as said). And then we would indeed have got distant objects with a *velocity* away from us, caused by expansion and measurable by their *redshift*, whilst their *distance* based on the primordial ruler does not change. The *Hubble time* and *distance* would be never changing universal constants.

Jeder sagte es geht nicht, aber einer wusste das nicht und der hat's gemacht.
Everyone said it's impossible, but somebody didn't know that and he did it.

A man said to the universe:
"Sir I exist!"
"However," replied the universe,
"The fact has not created in me
A sense of obligation."
Stephen Crane (1871-1900) (https://americanliterature.com/author/stephen-crane)



Hmmm...

Tutte le verità sono facili da capire una volta che sono state rivelate. Il difficile è scoprirle.
All truths are easy to understand once they have been revealed. The difficulty is to discover them.
Galileo Galilei (https://it.wikiquote.org/wiki/Galileo_Galilei)

Sì perché l'autorità dell'opinione di mille nelle scienze non val per una scintilla di ragione di un solo, sì perché le presenti osservazioni spogliano d'autorità i decreti de' passati scrittori, i quali se vedute l'avessero, avrebbono diversamente determinato.
So since the authority of the opinions of thousands in science is worth less than a spark of reason by an idividual, so because current observations strip of authority the decrees of former writers, had they seen it, they would have determined otherwise.
Galileo Galilei (https://www.goodreads.com/quotes/5658-s-perch-l-autorit-dell-opinione-di-mille-nelle-scienze-non-val)
(the above translation by myself is more accurate than what's found on this web page)

Quid est ergo tempus? Si nemo ex me quærat, scio; si quærenti explicare velim, nescio.
Then what is time? When nobody asks me, I know; but when I want to explain it, I don't.
Aurelius Augustinus Hipponensis, 354-430CE, Confessiones 11.14.