The **Cosmological Principle** says:

the universe is homogeneous and isotropic when viewd at a large enough scale. [1.]

This means the universe has more or less the same mass distribution and looks the same everywhere and in all directions, and the same laws of nature should apply everywhere. If we would not assume the latter we can immediately terminate cosmology. It is well in agreement with observed phenomena everywhere in the sky.

Albert Einstein postulated [*Zur Elektrodynamik bewegter Körper = On the electrodynamics of moving bodies*, 1905]:

1. **The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems of co-ordinates in uniform translatory motion.** This can be interpreted as: *the very same laws of nature apply to all observers, independent of their mutual velocity* (he calls this the **Relativity Principle** and primarily restricts it to constant *velocities*).
2. **Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity *V*, whether the ray be emitted by a stationary or by a moving body.** This means: *the Speed of Light has the same value for any observer independent of the velocity of the light source with respect to the observer.*

Ad 1: You know by your own experience that you must do everything in the very same way at whatever *speed*. You can just as easily eat your soup in the dining car of a high *velocity* train as you can at home. And in a jet airplane you also do all things the very same way. The same laws of nature always apply to everyone.

Ad 2: Einstein based this on the Michelson-Morley experiment, which showed that we always measure the very same *Speed of Light*, in spite of Earth's orbital movement at 30 km/s around the Sun and Earth's daily rotation also has no influence at all. Einsteins reasoning probably was: if we always measure the same, it must be a *Constant of Nature*. In his publication he states: *Wir setzen noch der Erfahrung gemäß fest daß die Größe V eine universelle Konstante (die Lichtgeschwindigkeit im leeren Raume) sei = We yet determine in agreement with experience that the quantity V be a universal constant (the velocity of light in empty space).* So to both postulates the following statement applies:

Ex Observatis Phænomenis Immediate Deductum Est.
= It has directly been deduced from observed phenomena.

In his next publication [*Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? = Does the inertia of a body depend upon its energy-content?*, 1905, about $E = mc^2$], Einstein referred to his earlier writing and in a footnote on page 1 he wrote: *das dort benutzte Prinzip der Konstanz der Lichtgeschwindigkeit ist natürlich in den Maxwellschen Gleichungen enthalten = the there used principle of the constancy of the velocity of light is of course contained in Maxwell's equations.* He had realized that in first instance he had missed a very important and fundamental clue! This means the second postulate is no longer a postulate since the constancy of the *Speed of Light* can be derived from Maxwell's Equations.

James Clerck Maxwell (Einstein refers to him in his very first sentence) had been able to describe all basics of electromagnetism/electrodynamics in a fundamental set of equations [*A Dynamical Theory of the Electromagnetic Field*, 1864]. From these equations follows that a *disturbance* in an *electric* or *magnetic field* propagates at a *velocity* given by:

$$v = 1/\sqrt{\varepsilon_0 \mu_0} \qquad [2.]$$

Where ε_0 and μ_0 are the *Electric* and *Magnetic Field Constants* respectively. Both are a *Constant of Nature* describing how easy an *electric* or *magnetic field* can "pierce" through empty space.

Maxwell himself gave an appearingly slightly different formula:

$$v = \sqrt{k/4\pi\mu} \qquad \text{(71 in his numbering)}$$

in which k is what Maxwell called the coefficient of "electric elasticity". Actually, it is the very same formula.

Surprisingly, the value of v appeared to be practically equal to the *Speed of Light*
as measured a few years earlier by Hippolyte Fizeau and by Léon Foucault!

About the measurement of the above ratio of k and μ, performed by Weber & Kohlrausch around 1856 using a Leyden jar, Maxwell wrote (in *part VI, Electromagnetic theory of light*): *the only use made of light in the experiment was to see the instruments*, and about Foucault's experiment he stated: *no use whatever was made of electricity or magnetism*. Then follows his conclusion thereabout: *The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws.*

There are phenomena such as *Faraday rotation* and *Thomson scattering*, which support Maxwell's suggestion that light is an electromagnetic wave. Visible light does interact with and is affected by magnetic fields and electrically charged particles, so it must be something electromagnetic. This simply implies: $c = v$, or:

$$c = 1/\sqrt{\varepsilon_0 \mu_0} \qquad [3.]$$

thus making the *Speed of Light* a *Constant of Nature* since both ε_0 and μ_0 are a *Constant of Nature*. They are *velocity*-independant properties of empty space, so the *Speed of Light* is a *velocity*-independant property of empty space as well. It is <u>not</u> a property of light, but of empty space or vacuum.

Since [2.] is built on observed phenomena from experiments with electricity and magnetism, and since the *Speed of Light* measurements are observations as well, we can once again say:

Ex Observatis Phænomenis Immediate Deductum Est.

Next is my own reasoning: since empty space itself is identical to all observers and emptyness cannot have its own *velocity* with respect to an observer, for all observers the *Speed of Light* must be identical and independent of their mutual *velocity*. So even without Einstein's Postulates it simply follows from Maxwell's Equations that:

the very same *Speed of Light* applies to all observers, independent of their mutual *velocity*. [4.]

When taken together, Einstein's postulates say the very same. It applies even if two observers measure the very same ray of light whilst having some non-zero mutual *velocity*. Based on this principle alone, Einstein derived what I will call the "Magic Relativity Factor":

$$\sqrt{1-(v/c)^2} \qquad [5.]$$

Actually, this is an application of the Pythagorean Theorem. This factor is of course used for *Time Dilation* and *Lorentz Contraction*. It easily follows from [5.] that it must always be that $v \leq c$ since the square-root of a negative number is physically impossible (forget about imaginary numbers, they're not real), so:

nothing can exceed the *Speed of Light*. [6.]

The formula for the superposition of *velocities* also follows from [5.] (§5 in Einstein's writing):

$$u = (v+w)/\left(1+\frac{v}{c}\cdot\frac{w}{c}\right) \qquad [7.]$$

As Einstein describes, this is always less than c if both $v < c$ and $w < c$ and when either $v = c$ or $w = c$ the result will be $u = c$, so the *Speed of Light* cannot be altered by superposition. This means that:

the *Speed of Light* cannot be reached if starting at a lower *velocity* [8.]

and it cannot be altered by superposition with any other *velocity*. [9.]

Together, [6.], [8.], and [9.] are what I will call the:

Speed Limit of Light Law:

Nothing can exceed the *Speed of Light* by whatever means, **the *Speed of Light* cannot ever be reached if starting at a lower *velocity*,** **the *Speed of Light* can in no way be altered by superposition of any other *velocity*.**

[10.]

Ex Observatis Phænomenis Immediate Deductum Est.

Superluminal *velocities* do simply not exist because they are fundamentally impossible. As Einstein wrote: *For velocities greater than that of light our deliberations become meaningless; we shall, however, find in what follows, that the velocity of light in our theory plays the part, physically, of an infinitely great velocity*. If you even think about a superluminal *velocity*, Einstein will turn around in his grave. On http://astronomy.swin.edu.au/cosmos/C/cosmological+redshift I found the following nonsense (2017-07-30): *(...) recession velocities, which can be greater than the speed of light. Note this doesn't break the ultimate speed limit of c in Special Relativity as nothing is actually moving at that speed, rather the entire distance between the receding object and us is increasing*. What a contradiction. Increasing *distance* (from some reference point and over *time*) **IS** a *velocity*. It's the definition. And of course those objects are moving with respect to us. As it says, their distance is changing. That's what we call movement. On another site I found arguments using the term *local frame* and it seems the author thinks it implies *nearby*. But only its reference points are nearby, the frame is infinite. For the derivation of [7.] Einstein uses a point moving at *velocity* w in a frame named k, which itself is moving at *velocity* v in a frame named K. It is about a moving point in a moving frame, not about *distance* and not even about an object.

I persist that even the *Expansion of the Universe* cannot ever exceed the *Speed of Light*. It is about bodies moving away from us together with their local space. One might think that the expansion causes an observer to flinch from an oncoming photon, but, according to [9.] the *Speed of Light* cannot be altered by superposition of *velocities*. Thus, the *velocity* due to the *Expansion of the Universe* can also not be subtracted from the photon's *velocity* with respect to the observer, which is the *Speed of Light*. So, once emitted, a photon travels at the *Speed of Light* with respect to the observer. Period. This means the *Light-Travel Time* depends only on the *proper distance* from the light source to the observer at the moment of emission, which then obviously equals the *Light-Travel Distance*, whatever the magnitude of the *Expansion of the Universe* during *Light-Travel Time*. In mathematical notation:

Light-Travel Time: $T_L = D_E / c$ [11.]

Light-Travel Distance: $D_L = c \cdot T_L = D_E$ [12.]

where D_E = *proper distance* from light source to observer at the moment of photon emission.

The Observable Universe.

The *Cosmic Microwave Background*, the CMB, is the "afterglow" of the big bang. It "origindates" from the big bang itself, before the recombination, when the universe was not yet transparent. Because of this intransparency the details of the big bang are lost. What we observe is the result of the recombination, lit by this big bang radiation. That's the CMB. It is the oldest entity that still exists. By the way, the recombination is only theoretical - there are to my knowledge no observable entities or quantities that really confirm it. According to the current status of science, the recombination was some 380 000 years after the big bang. And then, 399 620 000 years later or 400 million years after the big bang, star formation began. Nearly 14 billion years thereafter Homo Sapiens evolved on some tiny rock ball somewhere in space, at a place we call Earth. And he developed the second-oldest profession in the world: astronomy. Homo Sapiens observed the sky ever since and discovered the universe started with a big bang. But he only saw what's called the **Observable** (part of the) **Universe**. There is also a non-observable part of the universe. That is because some stars, galaxies, or whatever light sources are so far away that their light did not yet have time to reach us since the big bang.

Not enough time.

A) So the oldest existing radiation, the CMB, dating from the big bang itself and coming from as far away as ever possible, is being observed all the time, whilst the younger starlight dating from 400 million years later did not yet have time to reach us. Please explain. Using correct mathematics only. No fairy tales, please.

B) https://en.wikipedia.org/wiki/Chronology_of_the_universe states (text copied on 2017-07-28): The spherical volume of space which will become Observable universe is 42 million light-years in radius at this time. That is in agreement with the assumed CMB-*redshift* of circa 1100 and the assumed current *proper diameter* of the universe of ≈ 92 billion light-years: 92e9/2/1100 ≈ 42e6. So the mentioned sphere that has become the Observable Universe had a *diameter* of 84 million light-years. According to [11.] the *Light-Travel Time* for a full traversal then simply equals 84 million years.
Since only the mentioned sphere became the Observable Universe, any light source that was outside it is still not observable. Let's assume a light source just 1 meter outside it. Then it is still not observable. For that 1 meter a photon would require (1 m)/(c = 299 792 458 m/s) ≈ 3.34 nanoseconds. With a *Hubble constant* of $H_0 = 71$ km/s/Mpc the *Hubble time* equals $T_H = 13.7720$e9 years, so the recombination happened 13.7720e9 minus 380e3 = 13.7716 billion years ago. That is obviously not enough *time* for a 3.34 nanosecond + 84 million year travel, since we all know that a billion is far less than a million... Please explain. Using correct mathematics only. No fairy tales, please.

C) Or would that light source have moved into the sphere that became the Observable Universe, causing it to be observable? But then it was not outside the sphere that became the Observable Universe. How far must it have been outside that sphere to remain unobservable? Maybe it has overtaken its own unobservable light whilst entering the observable universe? Please explain. Using correct mathematics only. No fairy tales, please.

D) Suggesting an unobservable part of the universe or objects too far away for their light to have reached us in time, requires the *Expansion of the Universe* to go faster than light, but [10.] states that the *Speed of Light* cannot be exceed in whatever way. Not even the *Expansion of the Universe* can exceed the *Speed of Light*. Einstein never mentions any cause of a *velocity*. The cause is completely irrelevant, be it a rocket engine, the *Expansion of the Universe*, or whatever.

$$mutual\ velocity = \frac{change\ in\ distance}{time\ needed\ for\ that\ change} \qquad [13.]$$

whatever the cause of the *distance change*. And [10.] forbids any *velocity* to exceed the *Speed of Light*.

Challenge.

If you say the *Expansion of the Universe* can exceed the *Speed of Light* in whatever way, I challenge you - and it's your free choice to select item A, B, C, or D from the above list - to mathematically prove it, using only observed (that's not the same as observable) phenomena without making any ad hoc assumptions.

Proper size of the universe.

As mentioned above, the assumed current *proper diameter* of the universe is ≈ 92 billion light-years, so its *proper radius* equals 46 billion ly. In 13.77 billion years that would mean an average velocity of 3.34× c, which is a heavy violation of [10.]. And [10.] directly follows from [3.].
Any light source always moves away from an observer at a *subluminal velocity*. It might asymptotically approach the *Speed of Light*. This means that during the *Light-Travel Time* from source to observer, the source itself can at most travel the same *distance* further away. Of course this must be a relativistic *distance*, cumulatively Lorentz contracted according to every local *expansion velocity*. When persisting in the universal validity of [3.], which implies [10.], one must conclude that:

the *proper radius* of the Universe asymptotically approaches
two times the *Hubble Distance* and not even a yoctometer more. [14.]

Hubble's Law.

In 1929, Edwin Hubble discovered that galaxies move away from us with a *velocity* proportional to their *distance*. It means the universe is expanding. This became known as Hubble's Law:

$$v_H = H_0 \cdot d \qquad [15.]$$

Ex Observatis Phænomenis Immediate Deductum Est.

With v_H I mean *Hubble Velocity*, wich of course is the *velocity* resulting from Hubble's Law. Formulated in this way it is non-relativistic.

NOTE:
The assumption that now follows leads to an upper limit of the redshift that does not agree with observations,
but I leave it here for the purpose of making clear what my idea was,
and it contains quite some definitions and usefull formulas, so please keep on reading**.**

Suppose there are signs in the universe at many places, indicating the *Hubble Velocity* with respect to **here**. Then we "freeze" the expansion, but those signs still show their last value, and we travel to infinity at a non-relativistic constant *velocity*. [15.] says that we'll read a linearly increasing *velocity* on those signs, as if it were a uniform *acceleration*. Now let's go relativistic.

Relativistic Uniform *Acceleration*.

First of all, I define the usual dimensionless *velocity parameter* β as:

$$\beta \equiv v/c \qquad [16.]$$

Now suppose an object named X undergoes a constant *force* F_x and its *rest mass* is m_x. It is observed by an observer called W (Dutch for *observer* = *waarnemer*). The absolute value of their mutual *velocity* is the same for both, and it equals:

$$v = \frac{ds_x}{dt_x} = \frac{ds_w}{dt_w} \qquad [17.]$$

where s_x and t_x are the *distance* travelled and the *time* as experienced by X, respectively,

and s_w and t_w are of course the same, as seen and measured by W.

The *acceleration* experienced by X is: $$a_x = \frac{dv}{dt_x} = \frac{d\frac{ds_x}{dt_x}}{dt_x} \qquad \text{(of course } a_x = F_x/m_x\text{)} \qquad [18.]$$

For W there is *time dilation*: $$dt_w = dt_x/\sqrt{1-\beta^2} \qquad [19.]$$

as well as *Lorentz contraction*: $$ds_w = ds_x \cdot \sqrt{1-\beta^2} \qquad [20.]$$

so W sees: $$a_w = \frac{dv}{dt_w} = \frac{d\frac{ds_w}{dt_w}}{dt_w} = a_x \cdot (1-\beta^2)^{3/2} \qquad [21.]$$

or: $$\frac{d(\beta c)}{dt_w} = a_x \cdot (1-\beta^2)^{3/2} \qquad [22.]$$

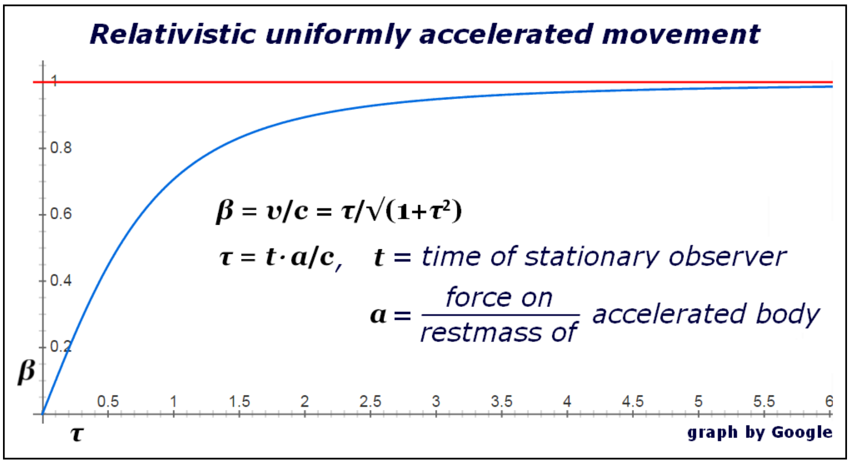
now substitute: $$\tau \equiv t_w \cdot a_x/c = t_w \cdot F_x/m_x c \qquad [23.]$$

τ is a dimensionless *time parameter*, like β being the dimensionless *velocity*.

then: $$d\tau = d\beta/(1-\beta^2)^{3/2} \qquad [24.]$$

integration results in: $$\tau = \beta/\sqrt{1-\beta^2}$$ [25.]

which finally yields: $$\beta = \tau/\sqrt{1+\tau^2}$$ [26.]



Relativistic Hubble's Law.

Now we use [26.] as a template for a relativistic formula for Hubble's Law. It will agree with [15.] at low *distances/velocities*, where [15.] is an observed phenomenon , and very far away it asymptotically approaches the *Speed of Light* without exceeding it, in accordance with [10.]. It also does not contradict [1.]. To my knowledge there are no observed phenomena contradicting such a Relativistic Hubble's Law.

The uniform *acceleration* pretended by the just mentioned frozen universe is seen whilst we travel at a constant non-relativistic *velocity*. And τ indicates the *time* of the stationary observer, which is linear and non-relativistic, so we can simply replace τ by a dimensionless *non-relativistic distance parameter* scaled in such a way that it is in accordance with the observed *Hubble constant* H_0.

The *Hubble Time:* $$T_H \equiv 1/H_0$$ [27.]

The *Hubble Distance:* $$D_H \equiv c \cdot T_H$$ [28.]

Dimensionless non-relativistic *distance parameter:* $$\rho \equiv d/D_H$$ [29.]

which we substitute for τ in [26.]: $$\beta = \rho/\sqrt{1+\rho^2}$$ [30.]

which, together with [27.], yields: $$v_H = H_0\, d/\sqrt{1+(H_0\, d/c)^2}$$ Bingo! [31.]

and conform [25.]: $$\rho = \beta/\sqrt{1-\beta^2}$$ [32.]

For smaller *distances* [31.] perfectly matches [15.] and for large *distances* it asymptotically approaches the *Speed if Light* without outpacing it. It is in perfect agreement with [10.] and [3.].

Lorentz Contraction.

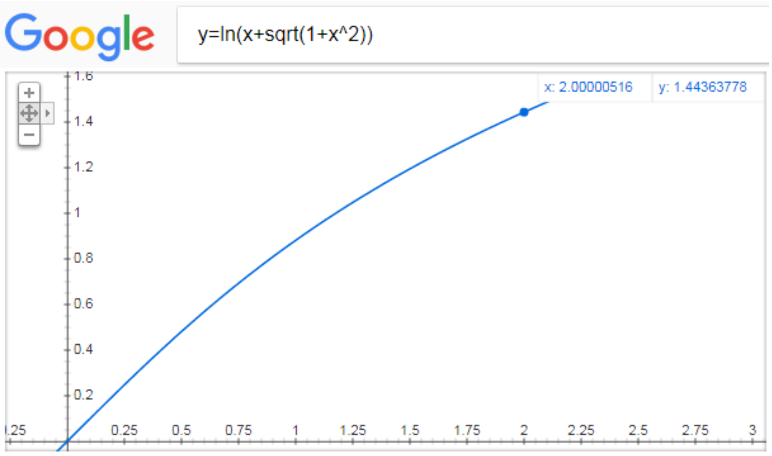
With this Relativistic Hubble's Law it is now possible to perform a cumulative or integrated *Lorentz Contraction* of the non-relativistic *distance*. The prime indicates that a quantity is cumulatively Lorentz contracted.

Infinitesimal *Lorentz Contraction*: $$d\rho' = \sqrt{1-\beta^2}\,d\rho$$ [33.]

because of [30.] this equals: $$d\rho' = \sqrt{1-\left(\rho/\sqrt{1+\rho^2}\right)^2}\,d\rho = \frac{d\rho}{\sqrt{1+\rho^2}}$$ [34.]

then, using x as integration variable: $$\rho' = \int_0^\rho \frac{dx}{\sqrt{1+x^2}}$$ [35.]

which yields: $$\rho' = \operatorname{arsinh}(\rho) = \ln\left(\rho + \sqrt{1+\rho^2}\right)$$ [36.]



As the graph shows, the cumulative or integrated *Lorentz Contraction* does not have a very dramatic effect.

The inverse of [36.] is: $$\rho = (e^{2\rho'} - 1)/2e^{\rho'}$$ [37.]

<u>Relativistic Hubble's Law,</u> <u>continued.</u>

Substitution of [37.] into [30.] yields: $$\beta = \left(\frac{(e^{2\rho'}-1)}{2e^{\rho'}}\right) \Big/ \sqrt{1 + \left(\frac{(e^{2\rho'}-1)}{2e^{\rho'}}\right)^2}$$ [38.]

which is a rather difficult way to say: $$\beta = \tanh(\rho')$$ [39.]

or: $$v_H = c \cdot \tanh(d'/D_H)$$ [40.]

and: $$\beta_H = \tanh(d'/D_H)$$ [41.]

where d' is the relativistic (cumulatively Lorentz contracted) *distance* to an object as seen by the observer.

<u>Expansion of the Universe during *Light-Trave Time*.</u>

Now suppose a light source emitted a photon to an observer at *distance* $d'(t_e)$ at *time* t_e. [12.] and [11.] then yield the *Light-Travel Distance* and the *Light-Travel Time*:

$$D_L = d'(t_e)$$ [42.]

$$T_L = D_L/c$$ [43.]

and the moment of observation is: $$t_o = t_e + T_L$$ [44.]

When <u>we</u> are the observer, then $t_o =$ <u>now</u> and $t_e =$ <u>now</u> minus T_L.

The *Hubble Velocity* does not change in time. The whole idea of the big bang came into being by assuming all objects have always had their current *Hubble Velocity* and then they must all have started emerging from a single point at a single moment. This constancy is also in perfect agreement with Newton's Laws, especially his Law of Inertia.

So now we can find the light source's *displacement* $\Delta d'$ due to the *Expansion of the Universe* during this *Light-Travel Time*, which, using [40.] and [12.], is:

$$\Delta d' = T_L \cdot v_H = D_L \tanh(D_L/D_H)$$ [45.]

of course: $$d'(t_o) = d'(t_e) + \Delta d' \quad [46.]$$

or: $$d'(t_o) = D_L + D_L \tanh(D_L/D_H) \quad [47.]$$

or: $$d'(t_o) = D_L\big(1 + \tanh(D_L/D_H)\big) \quad [48.]$$

The *Expansion of the Universe* during *Light-Travel Time* equals:

$$\zeta_E = d'(t_o)/d'(t_e) \quad [49.]$$

with [42.] and [48.] this becomes: $$\zeta_E = 1 + \tanh(D_L/D_H) \quad [50.]$$

Please note that [10.] and [14.] imply: $$\zeta_E < 2 \quad [51.]$$

Redshift.

There are three types of redshift, namely: *Doppler Shift* due to the velocity of the light source w.r.t. the observer (this can also be blueshift if a light source comes towards us), *Cosmological Redshift* due to *Expansion of the Universe*, which I will call *Expansional Redshift*, and *Gravitational Redshift, which* applies to light rays coming from a heavy *mass*.

Redshift is the increment of the *wave length* relative to the original *wave length*:

$$z = \Delta\lambda/\lambda_e = (\lambda_o - \lambda_e)/\lambda_e \quad [52.]$$

where λ_o and λ_e are the observed and emitted *wave lengths*. I think this is an inconvenient quantity - we practically always need to ad 1 to it. Therefore I define:

Redshift Factor: $$\zeta = \lambda_o/\lambda_e \quad (= z + 1) \quad [53.]$$

And then we have got:

Relativistic *Doppler Shift*: $$\zeta_D = \sqrt{(1 + \beta_H)/(1 - \beta_H)} \quad [54.]$$

Expansional Redshift = [50.]: $$\zeta_E = 1 + \tanh(D_L/D_H) \quad [55.]$$

This is not the "standard" formula (integral with different omegas), and [51.] clearly says: $\zeta_E < 2$

Gravitational redshift: $$\zeta_G = 1/\sqrt{1 - r_S/r} \quad [56.]$$

where: $r_S =$ *Schwarzschild radius* of light source

and: $r =$ *distance* from light source

Maybe you already noticed that I do not use much of General Relativity. But the *Expansion of the Universe* is an observed phenomenon which I can and will not ignore. In fact I am doing line-of-sight reasoning, and light follows geodesics, so whatever shape or curvature the universe has is irrelevant. And I simply do not take gravitational effects into account in this model. Besides, *Gravitational redshift* applies to light coming from a large *mass*, but it should not affect light that is passing by. That is first blueshifted whilst approaching the *mass* and the redshifted back to its original after passing the *mass*. So I simply presume $\zeta_G = 1$ and then I can leave it out.

The total *redshift* then becomes: $$\zeta = \zeta_D \cdot \zeta_E \quad [57.]$$

We have to insert [41.] in [54.] using [42.],

giving: $$\zeta_D = \sqrt{\frac{1+\tanh(D_L/D_H)}{1-\tanh(D_L/D_H)}} = e^{D_L/D_H} \quad [58.]$$

inserting [58.] and [55.] into [57.] yields:

Total *redshift*: $$\zeta = e^{D_L/D_H} \cdot \left(1 + \tanh(D_L/D_H)\right) \quad [59.]$$

or: $$\zeta = \frac{2e^{D_L/D_H}}{1+e^{-2D_L/D_H}} \quad [60.]$$

For $D_L = D_H$ we obtain: $\zeta = 4.7885$ which is far less than observed redshift values (highest measured as of 2017-08-01 = GN-z11 with a redshift of 11.09). This means the above derived Relativistic Hubble's Law cannot be correct. To me, it looked elegant, but alas.

So let's go back to [15.]

But of course I persist in the Speed Limit of Light Law. In another treatise [http://henk-reints.nl/Shape-and-size-of-the-expanding-universe.pdf] I opt for a model of the universe that in fact cuts of the *Hubble Velocity* at the *Speed of Light* in a very straight and self-evident way. I'll do the same here and simply rewrite Hubble's Law [15.] as:

$$\beta_H = D_L/D_H \quad [61.]$$

and according to [29.]: $$\rho = \beta_H \quad [62.]$$

Since [61.] is using the *Light-Travel Distance*, it automatically already is relativistic,

so: $$\rho' = \rho \quad [63.]$$

and then I can leave out the prime and simply use ρ. For the *redshifts* we get:

Relativistic *Doppler Shift*: $$\zeta_D = \sqrt{(1+\rho)/(1-\rho)} \quad [64.]$$

Expansional Redshift: $$\zeta_E = 1 + \rho \quad [65.]$$

Total Redshift Factor: $$\zeta = (1+\rho)\sqrt{(1+\rho)/(1-\rho)} \quad [66.]$$

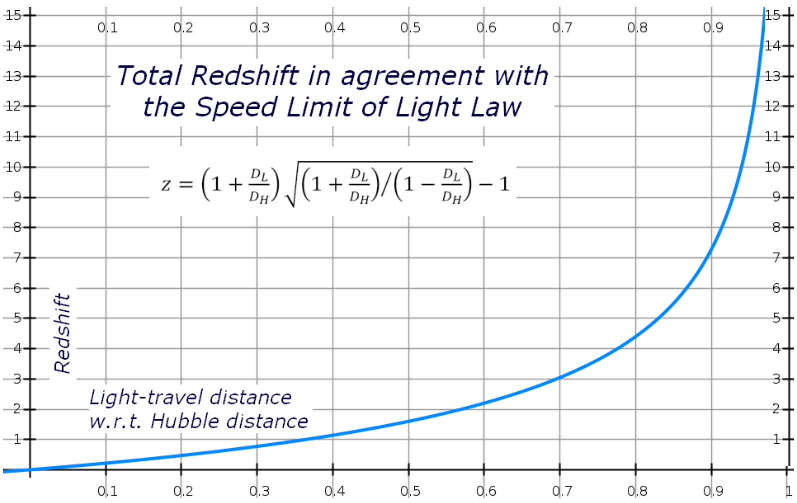
Since: $$z = \zeta - 1 \quad [67.]$$

We get for the "normal" *total redshift*:

$$z = \left(1 + \frac{D_L}{D_H}\right)\sqrt{\left(1 + \frac{D_L}{D_H}\right)/\left(1 - \frac{D_L}{D_H}\right)} - 1 \quad [68.]$$

and: $$\lim_{D_L \to D_H} z = \infty \quad [69.]$$

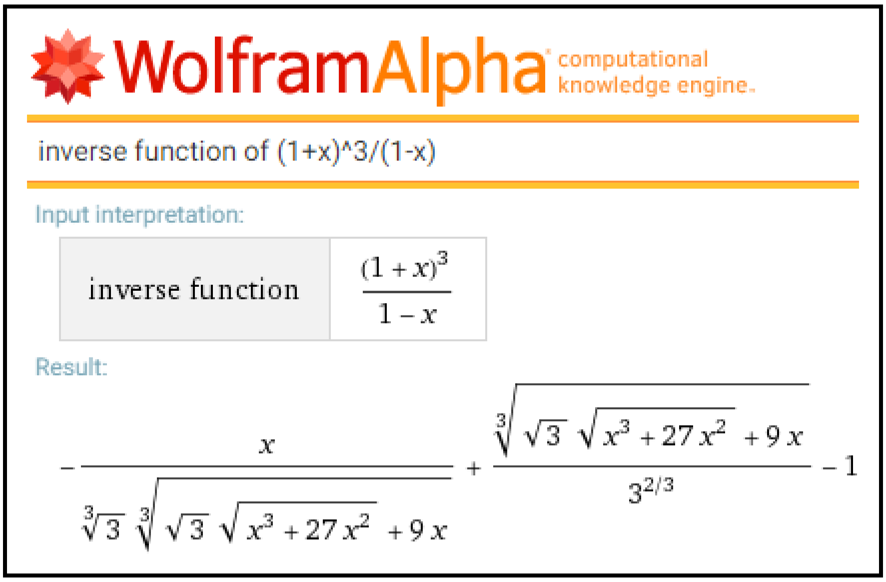
which does not conflict with observations.



[68.] can be inverted. First we rewrite it:

with: $\rho = D_L / D_H$ [70.]

we obtain: $(z+1)^2 = \zeta^2 = (1+\rho)^3/(1-\rho)$ [71.]



So, with: $x = (z+1)^2 = \zeta^2$ [72.]

and: $y = 9x + \sqrt{3x^2(x+27)}$ [73.]

we get: $\rho = \sqrt[3]{y/9} - x/\sqrt[3]{3y} - 1$ [74.]

The standard way to calculate *Light-Travel Distance* from *redshift* is:

$$\rho(z) = \frac{D_L(z)}{D_H} = \int_0^z \frac{dz\prime}{(1+z\prime)\sqrt{\Omega_r(1+z\prime)^4 + \Omega_m(1+z\prime)^3 + \Omega_k(1+z\prime)^2 + \Omega_\Lambda}} \quad [75.]$$

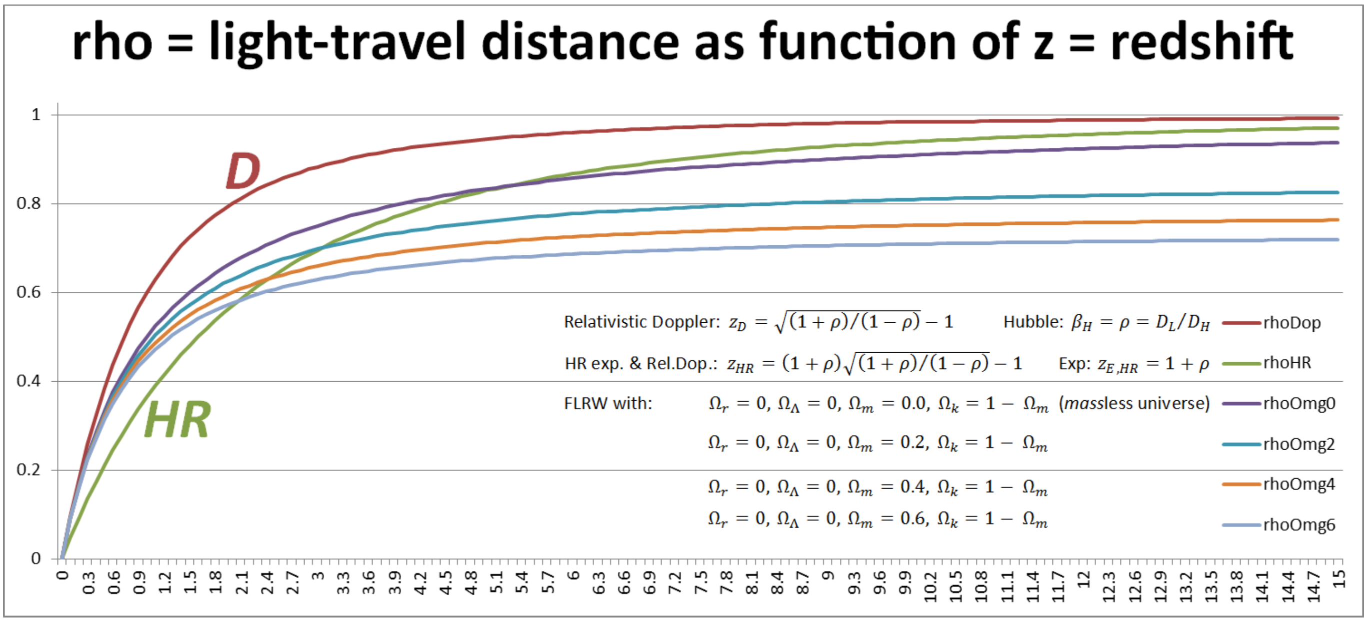
where: $\Omega_r = 0.266/3454$ = dimensionless *radiation density*
$\Omega_m = 0.266$ = dimensionless *matter density*
$\Omega_\Lambda = 0.732$ = dimensionless *dark energy density*
$\Omega_k = 1 - \sum \Omega_x$ represents the curvature of the universe

and that ugly square root in the denominator is called the *Hubble Parameter* $H(z)$, which follows from the Friedmann Equations (https://en.wikipedia.org/wiki/Friedmann_equations). A derivation can be found on: https://en.wikipedia.org/wiki/Hubble%27s_law#Derivation_of_the_Hubble_parameter and [75.] is found on: https://en.wikipedia.org/wiki/Distance_measures_(cosmology) (as of 2017-08-01), including the above Ω_x-values.

The inverse of [64.] (relativistic *Doppler Shift)* is:

$$\rho_D = (\zeta_D^2 - 1)/(\zeta_D^2 + 1) \quad [76.]$$

I did a (numerical) comparison of [74.], [75.] (with $\Omega_r = 0$, $\Omega_\Lambda = 0$, $\Omega_m \in \{0.0, 0.2, 0.4, 0.6\}$, $\Omega_k = 1 - \Omega_m$), and [76.], yielding:



Obviously, [74.] differs largely from the other and seems to be incorrect, which seems to suggest that

expansional *redshift* might not exist! [77.]

That would mean ojects in the universe are just moving away from each other in true *movement*.

Both [74.] and [76.] have been derived disregarding any gravitational effect.

What is also very clear is that the standard formula very much resembles the Doppler-only version and it does not put things farther away than the *Hubble Distance*, which is in agreement with the Speed Limit of Light Law and the fact that the light sources (stars, galaxies) must be younger than the big bang. So where are those galaxies whose light did not yet have *time* to reach us? Farther away than the big bang? *Superluminality* is fundamentally impossible. Special Relativity does also apply to very large *distances*. The term *local frame* does not mean *nearby*.

The various FLRW-curves show a larger *redshift* for greater *mass density*. Obviously, that must be *Gravitational Redshift*.

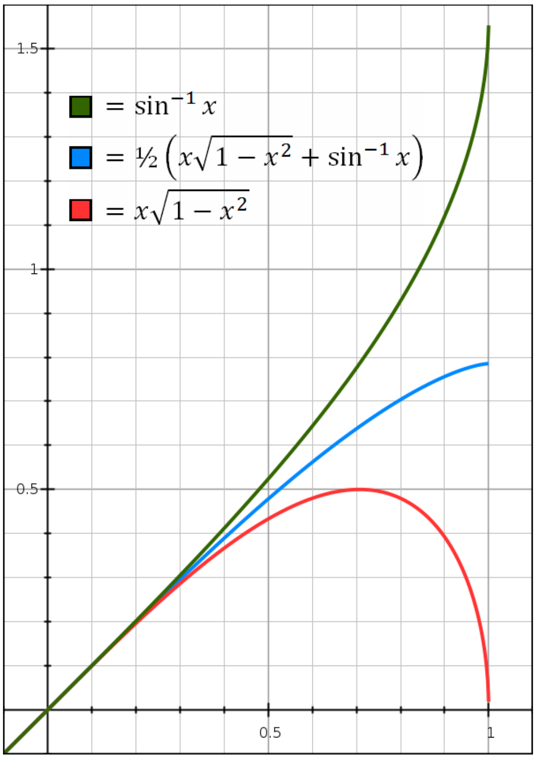
Regarding the difference between FLRW and Doppler the following. Suppose two *mass*less points moving away from an observer according to Hubbles Law, that is: they departed at the same *time* with different constant *velocities*. The observer is stationary, so for both points, he sees no *Lorentz Contraction* of space. But their mutual *distance* **is** Lorentz contracted due to their average *velocity* with respect to the observer. That seems paradoxal, but in Special Relativity, the *distance* you lose by *Lorentz Contraction* comes back as a *time difference*, so it still fits together. When applying Lorentz Contraction to all infinitesimal *distance differences* we get an *Integrated Lorentz Contraction* as follows:

$$\rho_{ILC} = \int_0^\rho \sqrt{1-x^2}\,dx \qquad [78.]$$

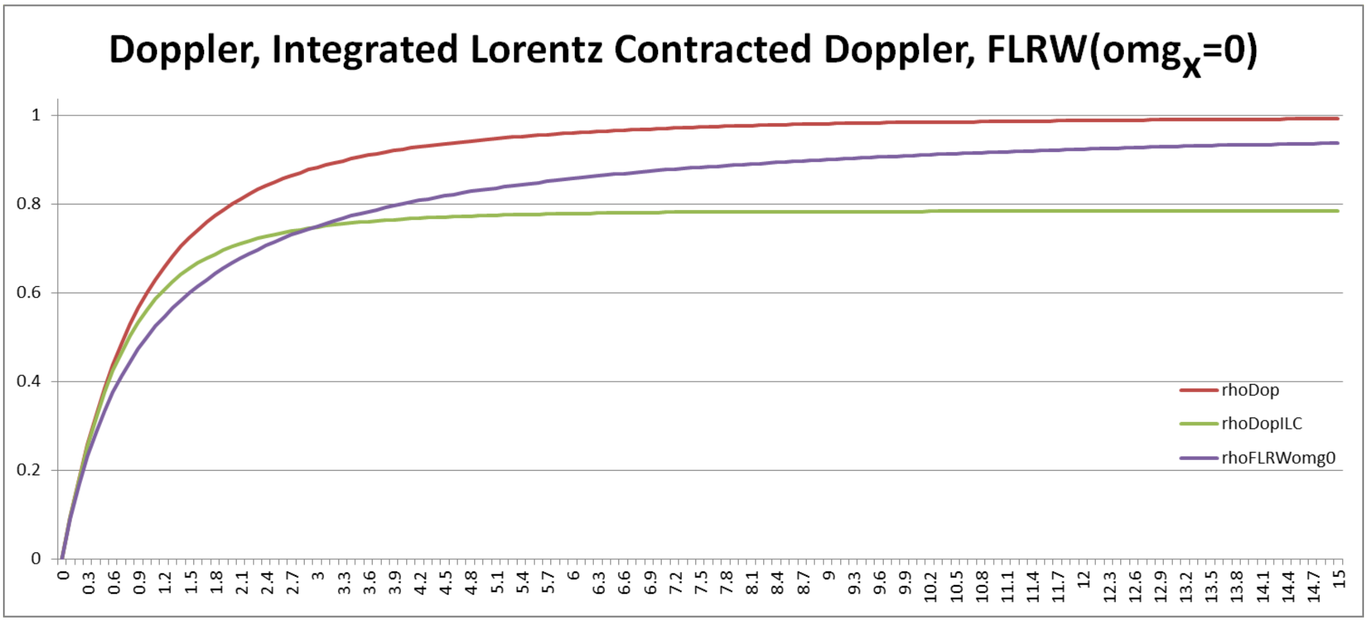
where: $x = \beta$ according to [61.] and [62.]

This yields: $$\rho_{ILC} = ½\left(\rho\sqrt{1-\rho^2} + \sin^{-1}\rho\right) \qquad [79.]$$

Below, this is the blue curve:



Application of [79.] to [76.] compared to FLRW with $\Omega_r = 0,\ \Omega_\Lambda = 0,\ \Omega_m = 0,\ \Omega_k = 1$ (empty universe) yields:



which does not explain the difference. I think it must be due to differences in geometry, where the Doppler-only model probably is too straight-forward.

But, regarding the first z-to-ρ graph, I earnestly doubt the very existance of *Expansional Redshift*. *Doppler Redshift* and Special Relativity follow from observations. *Gravitational Redshift* follows from General Relativy, which itself is built on Special Relativity and the Equivalence Principle (i.e. gravitation and inertia are actually the same), the latter (by induction) being based on the unobservability of any differences. But to me, *Expansional Redshift* is a figment of imagination. Which observation indisputably confirms it? Which theory actually predicts it? Absence of *Expansional Redshift* is in accordance with the Aristotelian dictum that whatever possessed dimensionality is body. Descarted said: *The space occupied by a body, is exactly the same as that which constitutes the body" (Pr II 10). Consequently, there cannot exist a space separate from body (Pr II 16).*

In order to measure *distance*, at least one base *distance* must be determined by counting the minimum number of equal things needed to connect two points. We usually call such a thing a *ruler*. Empty space itself has no reference points. The term *distance* is meaningless for a really empty space. And it contains nothing. Nothing at all. That's what "empty" means. So there is nothing that would be able to "pull" on a photon to stretch it.

And what is a wave? It is an oscillation, propagating with the wave *speed*, which is imposed on it by the medium. An oscillation happens in the *time* (or *frequency*) domain, and because of *movement* of source with respect to observer a *wave-travel time difference* occurs for succeeding oscillations, thus raising or lowering its observed *frequency*, which is the Doppler Effect. *Wavelength* is just a result of the oscilation *frequency* and the wave *speed* and in fact also a property of the medium, not of the wave. *Frequency* does not change in another medium. Compare light having the very same color in any type of glass. Color is NOT the *wavelength* but the *frequency*. The Doppler Effect occurs in the *time* or *frequency* domain, not in the "*wavelength* domain". Einstein derived the formula for relativistic curcumstances. What also occurs in the *time* domain is *Gravitational Time Stretching* (wrongly called dilaton - it's unilateral!). It follows from General Relativity. So both the *Doppler Effect* and the *Gravitational Redshift* occur in the *time* or *freuency* domain. They are real and can be calculated based on *velocity* or distance to a *mass*. Now think once again of *Expansional Redshift*. It does not occur in the *time* domain. What are the fundamentals behind the *frequency change* that needs to occur? As said, I think it does not exist at all.

Horizon problem.

When obeying the Speed Limit of Light Law, there exists no "horizon problem", since there is no horizon. [M1] applies to vacuum, which includes the inside of atoms (*proper volume* of the composing nucleons and electrons is approximately $1/10^{12}$ (one trillionth) of the *atomic volume*), but within an elementary particle there might be no vacuum at all, and then there is no such thing as a *Speed of Light*, and non-existing entities cannot impose a *speed* limit... In my treatise mentioned above, just before [61.], I calculated that if all matter in the universe would be compressed into one single very massive ball of close-packed neutrons without gravitational collapse, it would have a diameter of 3.67 au. I say that during the time from the big bang singularity to something of about that size, there existed no vacuum at all. Just like the *Speed of Light* being an intrinsic property of empty space, which can be seen as the medium through wich it propagates, such an initial universe without any vacuum could also have some intrinsic property being a velocity, for example the *Speed of Sound*. And I'm talking about a medium with practically infinite *incompressibility*, which would allow a very high *phase speed* of *pressure* waves. Maybe that might inform the entire thing of the very same laws of nature?
And I think quantum-physical experiments prove nothing at all regarding the *Speed of Light*, since quantum-entangled particles can be considered one single particle and relativity is not about *velocities* within an elementary particle. And don't quantum physics and relativity completely miss each other when extrapolating one towards the other?

***Redshift* of the CMB.**

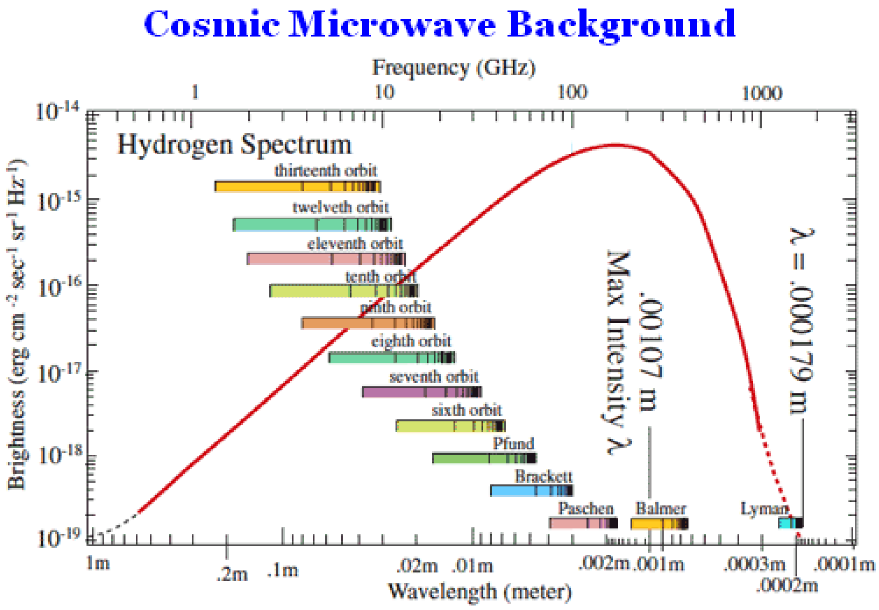
It is estimated as: $$z_{CMB} = \frac{T_{recombination}}{T_{CMB}} \approx \frac{3000\ \mathrm{K}}{2.72548\ \mathrm{K}} \approx 1100 \qquad [80.]$$

After the recombination, the entire universe was a sphere of 84 million light-years, as mentioned above. I replace that with my own estimate, based on [14.]:

Proper radius of universe: $$R_U = 2D_H \qquad [81.]$$

Diameter after recombination: $$D_{recomb} = 2R_U/1100 = \frac{D_H}{275} \approx 50\ \mathrm{Mly} \qquad [82.]$$

Then the entire universe was a cloud of hydrogen having a *diameter* of 50 million light-years. And that is when scattering of photons more or less finished, so it is the effective or apparent origin of the CMB. And the CMB is nearly perfectly in agreement with Plank's Radiation Law. Where are the remnants of the hydrogen spectrum?



How do we really know the recombination actually occurred? Which observations directly indicate the recombination? Is the *CMB-redshift* really equal to 1100?