Possible resolution of the twin paradox.

Henk Reints MSc. (Henk-Reints.nl)
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Summary

The twin paradox appears to be the result of an incorrect interpretation of how time dilation works. The paradox actually "exists" only in the past where the simultaneity of their births retrospectively seems to have been broken. Gravitational time dilation causes a bias in the moments both call *NOW*, wich is the actual asymmetry yielding different clock rates (cf. GPS). The clock hypothesis which ignores gravitational time dilation as a cause of different clock rates is therefore incorrect. The minimal observed proper age of distant objects appears to be $\approx 81\%$ of the Hubble time at z ≈ 0.73 or $\beta = \frac{1}{2}$.

Introduction

The ideal scenario in SR (special relativity) is perfectly symmetrical and both observers are equally right in observing one another. Because of their opposite perspectives, all results are antisymmetrical, leading to the twin paradox that yields an unrealistic ambiguity in which both see the other one's clock ticking slower, but observations (e.g. the Global Positioning System) reveal a unilateral difference in clock rates that cannot ever arise from a symmetrical scenario.

GR (general relativity), which in general is asymmetrical between two observers, would – in the usual interpretation – not be able to resolve this since it has only effect during the relatively short periods of acceleration and not as long as the velocity is constant as is the case during most of the journey.

The so called Clock Hypothesis says the difference in clock rates is caused by KTD (kinematic time dilation) only and not by GTD (gravitational time dilation). This does however not explain the unilaterality of this difference, hence the clock hypothesis is a paradoxical assumption that does not resolve the paradox.

Below is a derivation of how an asymmetry is actually induced by GTD and how KTD then becomes asymmetrical as well.

Twin paradox

KTD causes the time spans between successive ticks of a moving clock to be dilated (i.e. stretched) to the stationary observer. Each of the observers is stationary as seen from his own perspective, so both see the other one's clock tick slower. Then what if two initially synchronised clocks are brought together after a travel at a relativistic velocity?

From A's perspective we have:

$$\frac{\Delta t_A}{\Delta t_B} = \gamma_{AB} > 1 \tag{1}$$

and from B's perpective:

$$\frac{\Delta t_B}{\Delta t_A} = \gamma_{AB} > 1 \tag{2}$$

which obviously is a contradiction and not a paradox, but it has been coined the twin paradox. Einstein's first postulate restricts SR to linear uniform motion at a constant velocity, so the twins will never come together anymore, hence this contradiction does not falsify SR.

In § 4 of his original publication[1] Einstein already indicates the twin paradox scenario, starting at the fourth paragraph at the end of page 903. In the fifth paragraph he applies time dilation to points in time instead of to time spans...

GPS (global positioning system) may nowadays be considered one of the most frequently observed phenomena and the on-board atomic clocks have been corrected for time dilation. Apart from the GTD correction for the gravitational effect due to the height of the satellites (-45 µs/day) there is a correction of 7 µs/day for KTD due to the orbital velocity of the satellites. The accuracy of GPS confirms there is indeed a nonzero KTD effect, which is in disagreement with the symmetry of the SR scenario.

Clock hypothesis

The clock hypothesis says GTD does not contribute to the difference in clock rates. Newton's rule of reasoning no. IV in book III of his Principia says however that arguments obtained by induction (i.e. derived from phenomena) should not be set aside by assumptions. Einstein drew conclusions from observed phenomena, which is the whole reason why his theory is so strong, whilst the clock hypothesis is just an assumption. Since GTD applies only to the accelerated or gravitated observer it is fundamentally asymmetrical, whilst - in an ideal SR scenario - KTD is fundamentally symmetrical. Then GTD can be the only effect that induces the asymmetry in the clock rates as confirmed by for example GPS. The clock hypothesis does not explain this asymmetry in any way.

Another twin paradox

An essential premise of SR is that both observers are equally right and since the ideal SR scenario is fully symmetrical they continually agree on their mutual (constant) velocity v. For the very same reasons they must perpetually agree on their mutual distance d as well. The time elapsed since their passage (where of course $d = 0$) then equals:

$$\Delta t = d/v \tag{3}$$

Since both observers constantly agree on both d and v it must continuously be that:

$$\Delta t_A = \Delta t_B \tag{4}$$

which means they perpetually agree on the time elapsed since their passage. This means that if both observers synchronised their identical clocks to zero when the passage took place, these clocks from then on uninterruptedly show the same time elapsed, so they are running fully synchronously. Each clock tick can only be observed as it occurs, hence it cannot be otherwise than that all *current clock ticks* of both observers will coincide again and again, resulting in not the slightest age difference between A and B.

Another way to see this is next scenario. We will mark the geometric barycentre (midpoint between A and B) as point C and then of course the passage of A and B takes place right there. Both A and B have a constant velocity w with respect to it, in opposite directions, such that

$$\frac{2w}{1+\frac{w^2}{c^2}} = v \tag{5}$$

which is their mutual velocity.

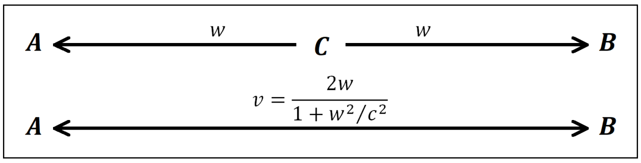

Fig.1: *A and B with central point of passage C at geometric barycentre*

Now a clock perpetually resides at C and both A and B count its ticks. In this perfectly symmetrical scenario between A and B where C is one single clock it cannot be otherwise than that both A and B uninterruptedly read the very same value on it, they count the same number of its ticks. This implies that clocks A and B must perpetually tick perfectly simultaneously, no matter whether they perceive time dilation of clock C or not, since that is identical to both of them. They would apply the very same correction to adjust their own clocks.

The effect of time dilation would be that a moving clock ticks slower than a stationary one. Then clock C would tick slower than A or B by $\gamma(w)$ and due to the symmetry this would be the very same Lorentz factor for A and B. Then they would still see their mutual clocks tick at the same rate. Due to their own mutual velocity however, they would see one another's clock tick slower by $\gamma(v)$. The premise of moving clocks ticking slower than stationary ones obviously yields a contradiction and not a paradox.

A moving clock ticking at the same rate as a stationary one seems in disagreement with time dilation. Einstein correctly derived the latter from facts of experience so we should not tamper with it. Then the standard interpretation of how time dilation manifests must be wrong.

Time dilation factor

When applying the twin paradox scenario to a triplet $\{A, B, C\}$ with

$$0 < \beta_{AB} < \beta_{AC} \;\therefore\; \beta_{BC} > 0 \tag{6}$$

where both B and C simultaneously return to A we obtain as observed by A:

$$\frac{\Delta t_A}{\Delta t_B} = \gamma_{AB},\; \frac{\Delta t_A}{\Delta t_C} = \gamma_{AC} \;\therefore\; \frac{\Delta t_B}{\Delta t_C} = \frac{\gamma_{AC}}{\gamma_{AB}} \tag{7}$$

and as observed by B we have:

$$\frac{\Delta t_B}{\Delta t_C} = \gamma_{BC} \tag{8}$$

so it must be that:

$$\gamma_{BC} = \frac{\gamma_{AC}}{\gamma_{AB}} \;\therefore\; \gamma_{AC} = \gamma_{AB}\gamma_{BC} \tag{9}$$

Einstein's velocity addition theorem:

$$\beta_{AC} = \frac{\beta_{AB} + \beta_{BC}}{1 + \beta_{AB}\beta_{BC}} \tag{10}$$

yields:

$$\gamma_{AC} = \gamma_{AB}\gamma_{BC} + \sqrt{\left(\gamma_{AB}^2 - 1\right)\left(\gamma_{BC}^2 - 1\right)} \tag{11}$$

and from (9) and (11) together we obtain:

$$\begin{gathered}\sqrt{\left(\gamma_{AB}^2 - 1\right)\left(\gamma_{BC}^2 - 1\right)} = 0\\ \therefore\; \gamma_{AB} = 1 \vee \gamma_{BC} = 1\\ \therefore\; \beta_{AB} = 0 \vee \beta_{BC} = 0\end{gathered} \tag{12}$$

which obviously contradicts the premise given by (6).

This means the Lorentz factor cannot apply to the twin paradox scenario, which should be obvious since this scenario is longitudinal. If B and C where coherent light sources then the number of wave periods received by A truly reflects their respective ages, so we clearly have to apply the Doppler factor:

$$\zeta := z + 1 = \sqrt{\frac{1+\beta}{1-\beta}} \tag{13}$$

on the way out and its reciprocal on the way back. For the way out we then obtain as observed by A:

$$\frac{\Delta t_B}{\Delta t_C} = \frac{\zeta_{AC}}{\zeta_{AB}} \tag{14}$$

and as observed by B:

$$\frac{\Delta t_B}{\Delta t_C} = \zeta_{BC} \tag{15}$$

so it must be that:

$$\zeta_{AC} = \zeta_{AB}\zeta_{BC} \tag{16}$$

or:

$$\sqrt{\frac{1+\beta_{AC}}{1-\beta_{AC}}} = \sqrt{\frac{1+\beta_{AB}}{1-\beta_{AB}}} \cdot \sqrt{\frac{1+\beta_{BC}}{1-\beta_{BC}}} \tag{17}$$

On the way back all βs will just have opposite signs. Given (10) it is clear that (17) is always true. Therefore we must conclude that in a longitudinal scenario the Doppler factor must be used instead of the Lorentz factor. The Lorentz factor remains correct in a transverse scenario such as GPS (given the nearly constant satelllite height of over 20 000 km).

From now on, we will use the symbol η for the TDF (time dilation factor), be it the Lorentz factor, the longitudinal Doppler factor, or the relativistic Doppler effect in general.

Local frame

A major aspect of relativity is that each observer perceives the universe from his own point of view. Only his own perspective is what matters to him. This means he is fixed at the origin of his local frame. And a local frame spans the entire universe, only its reference points are local.

And for each observer, it always is *NOW*. Whenever he observes some event, he calls it *NOW*. Every thought of his occurs at a moment he calls *NOW*. He performs any of his actions at a moment he calls *NOW*. The past IS no more, the future IS not yet, only the present IS; one has only a current remembrance of the past, a current expectation of the future, and a current observation of the present[2]. One lives *NOW* and only *NOW*. Not in the past, nor in the future. *NOW* you started reading this very sentence, *NOW* you are halfway through and you will stop reading it right *NOW*. On his proper time line, the observer always resides at a moment he calls *NOW*. The fundamental concept of time is only meaningful with respect to *NOW*.

And, as just mentioned, the observer always resides in the origin of his local frame, where all coordinate values equal nought. Then it must be that $t = 0$ only applies to *NOW*, so $t = 0$ is synonymous to *NOW*. This is in accordance with the full synchronicity of the twins as given by (4), as well as the full equivalence of both observers. For each of them it always is *NOW*, i.e. $t = 0$. And *NOW* is always the moment of observation in the observer's proper time. The only useful temporal point of reference is *NOW*. And each observer has its own proper *NOW*, which is uninterruptedly fixed to the origin of his local frame.

Single event

Apart from the signal travel time, a single event can only be observed when it takes place. This means that a single event can only be observed simultaneously by all observers and each of them says it occurs

$$NOW. \tag{18}$$

Kinematic time dilation

At the very end of an observed time span it cannot be another point in time than *NOW*, so an observed time span always occurred in the past and KTD applies to time spans with respect to *NOW*. When we define t_0 as the start of this time span to which time dilation applies, i.e. the timestamp of some past event, then

its duration equals:	$\Delta t \quad = NOW \quad - t_0$
and therefore:	$\Delta t_A \quad = NOW_A - t_{0,A}$
as well as:	$\Delta t_B \quad = NOW_B - t_{0,B}$
and according to the above:	$NOW_A = NOW_B = 0$

For B's time span as observed by A we obtain:

$$\Delta t'_B = \eta \cdot \Delta t_B \ \therefore\ t'_{0,B} < t_{0,A} < 0 \tag{19}$$

and similarly:

$$\Delta t'_A = \eta \cdot \Delta t_A \ \therefore\ t'_{0,A} < t_{0,B} < 0 \tag{20}$$

Hence, as seen by A, B's t_0 was before A's, and as seen by B, A's t_0 was before B's, so both see the other one's t_0 (the timestamp of the past observation of a bygone event) to have occurred earlier than his own, but in agreement with (4) their respective *NOW*s perpetually coincide.

Now consider the twins once again. The observed time interval since their birth and departure always is in the past and it underwent KTD. While they are moving apart we have $\eta > 1$ and because of (4) both must remain of the very same age. After a while (in their respective frames) each of them will say his sibling was born longer ago but not earlier (sic). Only the start of this past time interval is retrospectively paradoxical, but *NOW* there is no paradox at all. Both will say: *We were born together, but NOW it seems my sibling was born way before me and then lived slower at a rate such that we NOW have the same age.*

In the stationary observer's proper past an elapsed time of the moving one is stretched by KTD, so moving events are deeper in the past, but when the event actually occurred, both called it *NOW*. But *NOW* that's a past *NOW*. The stationary observer sees the event of the moving one's observation receding faster than what this moving observer sees himself, so in the stationary's past the moving clock's last tick is longer ago than in that clock's own past, hence it appears to the stationary observer that the moving clock has ticked slower by a factor of η, but the current tick occurs *NOW*. KTD applies to the past.

Observations will be consistent when an event takes place, whilst retrospections become paradoxical. If the event was beheld by both observers then each of them will say:

> *Your observation occurred longer ago in my proper time than in yours, in spite of the fact that it was one single event when it took place. Nevertheless, we are NOW living synchronously.*

$$\text{(retrospective KTD)} \tag{21}$$

Consider the Rossi-Hall and the Frisch-Smith experiments regarding muon decay. At a moment he calls *NOW*, an observer at a low altitude detects a muon that originates from a high altitude. In this observer's proper time, the time elapsed since the muon's genesis (which equals its travel time) exceeds its decay time, so it should no longer exist. But it is detected. Since for both observer and muon the detection occurs *NOW*, the muon's genesis occurred a longer time ago in the observer's proper time than in the muon's proper time, so in the observer's proper time the muon is older than in its own. There is no paradox at all, not even in the past, since the muon's high-altitude genesis was not perceived by the low-altitude observer.

Also consider a photon from say the Andromeda galaxy. Thanks to KTD its entire travel distance is Lorentz contracted to nought point nought since it has the speed of light. Therefore it experiences zero time during its travel. Then for the photon itself its departure was zero time ago, but for us it was $2\frac{1}{2}$ million years ago, and both for the photon and for us it is *NOW* when we observe it. There is no paradox at all, not even in the past, since the photon's distant genesis was not actually observed by us.

Just like the muon's genesis seems longer ago to the stationary oberver than the muon's proper age would allow, the stationary twin retrospectively sees his sibling to have been born longer ago than the age he *NOW* has.

Relevant time spans are to be considered with respect to *NOW*. In the stationary's past, the moving one's time spans with respect to *NOW* are stretched by KTD, so the moving one's "far end" of the time span is further away from *NOW* than one's own. The stationary observer sees the moving one's observation of a past event to be receding faster in his own stationary past that what the moving observer perceives.

The moving last clock tick gets behind the stationary last clock tick hence it pretends to have occurred before it although they actually did occur simultaneously, so the moving clock retrospectively appears to have ticked slower, but both current clock ticks occurring *NOW* are simultaneous.

The moving one's past is deeper in the stationary's history, but that can only be by reasoning, not by observation (cf. the not observed genesis of the above muon or foton). One cannot observe the past since it no longer IS. Observations can only be made *NOW*.

Of course it must be similar for future time spans, which cannot be observed yet. The moving one's future is stretched in the stationary's future and, like moving past events are receding faster, moving future events are approaching faster. The moving observer announces he will give a flash of light in 1 second and the stationary observer expects it to be say $1\frac{1}{2}$ seconds in *his* future. But, as paradoxical as it may seem, when the flash is actually there, both will observe it simultaneously as it takes place as a single event, in agreement with (18). The stretched future time span the stationary observer "saw" on beforehand has become compressed and both observe the flash *NOW*.

It means that in the stationary's past a moving clock appears to have ticked slower and in his future it will tick faster, but *NOW* both clocks are synchronous. This is similar to blueshift on approach and redshift when an object is moving away.

Perception of clock rates: (22)

> In any observer's past a moving clock retrospectively ticked slower than a stationary one and in his future it will prospectively tick faster, but both *NOW* occurring *current clock ticks* coincide perpetually.

In SR, each observer can be considered stationary and the other one moving. In a perfect SR scenario they grow old at the very same rate and their clocks are running fully synchronously. Any paradoxes due to KTD "exist" only in the past or future. Future paradoxes will automatically become resolved and paradoxes that arise by retrospection are irrelevant. That is how KTD works. It stretches both the past and future with respect to *NOW*, which is fixed to the origin of each observer's local frame, and the *NOW*s of both observers perpetually coincide, so single events will be observed simultaneously in agreement with (18).

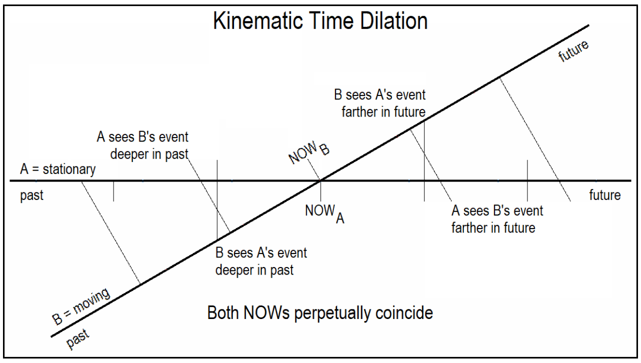

Fig.2: *KTD is just and only the obliqueness of the time line of a moving observer, as seen by the stationary one. Its timestamp lines are perpendicular to it, intersecting the stationary time line farther away from the common NOW. The resulting perspective distortion causes moving time spans to become stretched to the stationary observer (and vice versa).*

Gravitational time dilation & asymmetry

As long as both observers undergo different accelerations, GTD is asymmetrical between both observers. Assuming A is in inert motion and B is accelerating, B's proper time spans are longer in A's proper time, and A's proper time spans are shorter in B's proper time, so B is aging slower than A. This would cause NOW_B to shift into A's past, since A has already exceeded B's corresponding age. Similarly, NOW_A shifts into B's future, since B has not yet reached A's age. This yields a bias in their proper *NOW*s. After some acceleration by B, A lives in B's future and B lives in A's past. This bias would be the actual asymmetry that arises from GTD. See appendix I for a simple derivation, which yields:

$$\Delta t_{NOW} = \Delta t_A \cdot \left(1-\gamma^{-1}\right) = \Delta t_B \cdot (\gamma - 1) \qquad (23)$$

It obviously depends only on B's ultimate velocity and the duration (not magnitude) of his acceleration.

We define:

immediate past:

proper Δt from *NOW - bias* to *NOW*,

immediate future:

proper Δt from *NOW* to *NOW + bias*,

present time span:

proper Δt from *NOW - bias* to *NOW + bias*.

Then, after GTD has done its thing, B's immediate future fully coincides with A's immediate past and A's immediate past exactly overlaps B's immediate future, so B's entire present time span is in A's past and A's entire present time span is in B's future.

So, according to (22), KTD causes A to see B aging slower since B lives in A's past, whilst B sees A aging faster since A lives in B's future.

Lo and behold, this is asymmetrical KTD, Q.E.D.

As long as KTD applies, i.e. $\beta \neq 0$, there will now be a truly asymmetrical difference in the clock rates. The bias in their respective *NOW*s will grow at a rate determined by the TDF, so their *NOW*s will shift more and more apart. This is the difference in clock rates that yields the divergence of their ages. And it equals the correction that is applied to the clocks in the GPS satellites, thus proving asymmetrical KTD. Any further accelerations (at turning around and braking on return) will add their own resulting bias to this age difference. The ultimate age difference will be the sum of all biases plus the KTD effect because of the dissimilarity in the clock rates. Of course the KTD effect is proportional to the duration of the journey and to the TDF. In a longitudinal scenario it in fact is redshift during B's way out and blueshift on his way back.

Once the twins meet again there will not be any paradox or contradiction, but B will have to resynchronise his clock, since he is really younger than A. He can of course not adjust his age. The twins will no longer have any joint birthday.

It does not really matter how small the initial bias is, as long as it is nonzero. Perfect symmetry with a zero bias is only possible in an ideal SR scenario or when both observers would undergo really identical accelerations. Such ideal circumstances are unrealistic, certainly in case of certain uncertainties, like quantum effects. Any asymmetry, no matter how small, induces a nonzero bias and from then on, KTD will have its effect.

Stability of the (a)symmetry

Both observers perceive in their own proper time that the other one's time spans are stretched by KTD. This includes the bias. Any stochastical time fluctuation in one of the proper times will in the other time immediately be magnified by η. The next time fluctuation has the same expected value, hence the odds are 50⁄50 that it occurs in the same or in the other proper time, so on average it is too small to compensate the prior. In other words: a zero bias is an unstable equilibrium.

Heisenberg's uncertainty principle implies there always is a nonzero inaccuracy in time measurements, yielding $NOW_A \neq NOW_B$, so a truly zero bias cannot really exist.

In normal life, A and B almost continuously undergo different accelerations. One moment B accelerates more than A, causing A to outpace him and become the older one, the next moment A accelerates more than B, causing B to catch up and overtake A, making him the older one. Since $v_{AB} \lll c$ and very little time passes until the sign of their acceleration difference changes, their bias will show just a minute fluctuation around zero, so there will never grow a significant age difference. But after a long space travel at a high enough velocity an astronaut will persistantly be younger than those who kept their feet firmly on the ground. The relevant bias was induced by GTD during launch and then KTD made it steadily grow to a significant value during the astronaut's entire travel time at a high velocity.

The above is also in agreement with the Hafele-Keating experiment (flying around the world). For GPS there is of course a persistent gravitational effect, but the total correction includes asymmetrical KTD, causing GPS to yield correct results. The bias was of course induced during launch of the satellites.

Clock hypothesis once again

In his Regulæ Philosophandi (rules of reasoning), Newton formulated Ockham's razor as: *We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.* The clock hypothesis cannot be true since it incorrectly denies the influence of GTD which actually induces the required asymmetry that truly resolves the twin paradox.

Important consequence of retrospective KTD

In agreement with the Cosmological Principle, the "Yonder galaxy" measures the same Hubble constant as we do. Of course Yonder and us mutually measure the very same redshift, hence we agree on our mutual velocity. With the same Hubble constant we then also perpetually agree on our mutual distance and obviously on the age of the universe since that is the reciprocal of the Hubble constant.

In fact, Yonder and us are like a pair of twins, born at the big bang, which for both was the Hubble time ago. Yonder measures it in *its* local frame, we in *ours*. Of course KTD applies to Yonder and us as described above. This means Yonder's Hubble time is dilated to us, towards the far past, way before the big bang as it occurred in *our* time frame. Evidently, the same applies to any galaxy, so in our local frame it appears as if we were expelled from the big bang as the very last object.

So what existed before the big bang?
The entire universe, except us.

This is valid in our proper time frame. But the very same applies to any galaxy. From its own perspective, every galaxy is the youngest of all objects in the universe. It simply means that in *our* local frame, Yonder is way older than us:

$$t'_{\mathrm{H}} = \eta \cdot t_{\mathrm{H}} \tag{24}$$

Yonder's current age in our local frame equals its proper age (which equals the Hubble time) dilated by the TDF corresponding to Yonder's velocity. Yonder's light came to us during some light travel time Δt_{L} as perceived by us in *our* local frame. Of course it was emitted at $t = NOW - \Delta t_{\mathrm{L}}$ in *our* frame. Yonder's dimensionless age when it emitted the light is then given by:

$$\alpha_{\mathrm{Y}} = \frac{t'_{\mathrm{H}} - \Delta t_{\mathrm{L}}}{t'_{\mathrm{H}}} = \frac{t_{\mathrm{H}} - \Delta t_{\mathrm{L}}/\eta}{t_{\mathrm{H}}} \tag{25}$$

$$\alpha_{\mathrm{Y}} = 1 - \frac{\Delta \tau_{\mathrm{L}}}{\eta} \tag{26}$$

where $\tau = t/t_{\mathrm{H}}$ is the dimensionless time.

So the lookback time in Yonder's proper time is just $\Delta t_{\mathrm{L}}/\eta$ and not Δt_{L}. We have to apply inverse KTD to the light travel time in order to obtain the correct value.

A correct derivation of the Hubble-Lemaître law (see appendix II) without assuming superluminality and eliminating the fictitious horizon problem, yields the true dimensionless light travel time (in *our* frame, scaled to the Hubble time) as:

$$\Delta \tau_{\mathrm{L}} = \frac{\beta_{\mathrm{H}}}{1 + \beta_{\mathrm{H}}} = \frac{\zeta^2 - 1}{2\zeta^2} < \frac{1}{2} \tag{27}$$

As is obvious from this equation, the lookback time as perceived in *our* frame can in no way ever exceed half the Hubble time. Since galaxies are observed longitudinally we put $\eta = \zeta$ and then the combination of (26) and (27) yields:

$$\alpha_{\mathrm{Y}} = 1 - \frac{\zeta^2 - 1}{2\zeta^3} \tag{28}$$

which has a minimum of

$$1 - \frac{1}{3\sqrt{3}} \approx 0.808 \text{ at } \zeta = \sqrt{3} \text{ or } \beta = \frac{1}{2} \tag{29}$$

It simply means that subtraction of the light travel time as perceived by us from *NOW* in *our* frame in order to obtain a distant object's proper age when it emitted this light is comparing apples to oranges. The light travel time is valid in our stationary frame only, whilst the distant object is moving away at a great velocity, causing KTD. Moreover, standard cosmology seems to presume a way too large light travel distance which actually is the current proper distance, see appendix II and appendix III. It should be evident that a too large light travel distance or lookback time yields a too low presumed age of distant objects[3].

We cannot observe very young distant objects because we observe their proper age largely time dilated due to their Hubble velocity. The youngest we can observe has an age of $\approx 81\%$ of the Hubble time at z ≈ 0.73 or $\beta = \frac{1}{2}$ and the proper age of very distant objects approaches the Hubble time. We may look back quite far in *our* proper time (but according to (27) not further than $\frac{t_{\mathrm{H}}}{2}$, any older light already passed us), but not in *its*, since that is dilated to us to way before the big bang.

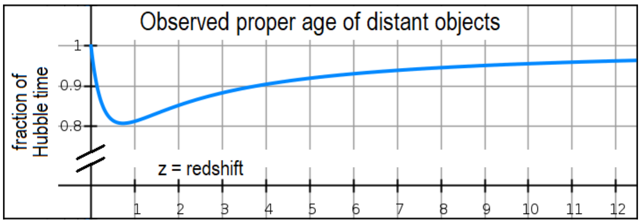

Fig.3: *Observed distant proper age as a function of redshift*

This finding is in accordance with several publications reporting the maturity of distant objects which are (mistakenly) presumed young objects. See the references list below[3,4].

It also gives rise to what could be called the "emitted speed of light":

$$c_{\mathrm{e}} = \eta \cdot c > c \tag{30}$$

and it is irrelevant that this exceeds the normal speed of light because that is meaningless to the light source which just got rid of some energy. Einstein's 2nd postulate also relates the speed of light to the observer only. He also wrote that the speed of light plays the role of the infinite velocities and this emitted speed of light goes to infinity with increasing redshift. It equals the proper distance divided by the inversely dilated light travel time, which is a pseudo velocity since no two objects ever change their mutual distance at that celerity.

Lorentz-Fitzgerald contra(di)ction

Consider the well-known example of a train going through a tunnel at a relativistic velocity. At rest they are of the same length. When the train is speeding, the tunnel is contracted as seen from within the train so it is shorter than the train. As seen by an observer who is stationary with respect to the tunnel, the train is contracted so it is shorter than the tunnel.

From within the train we observe the tunnel passing by:
1. entrance of short tunnel swallows front of normal train;
2. exit of tunnel passes front of train;
3. entrance engulfs rear end of train ;
4. exit of tunnel passes rear end of train.

The stationary observer sees:
1. front of short train enters entrance of normal tunnel;
2. rear end of train enters entrance;
3. front comes out of the exit;
4. rear end leaves the exit.

Now suppose the train is red, but at the exit of the tunnel somebody sprays blue paint on the train's front. The front leaving the tunnel and being painted are to be considered a single event since they occur simultaneously at one and the same location.

What color does the train's front have
when its rear end passes the tunnel entry?

In the above standard scenario the people inside the train will say the exit of the short tunnel already passed the train's front which has thus already been painted blue, whilst the stationary observer persists that the short train is yet fully inside the tunnel, including its still red front.

The train's rear end entering the tunnel is a single event, which according to (18) must be observed simultaneously by both observers at a moment they call *NOW* as they see it happen. The train's front leaving the tunnel and being painted is a single event as well...

We can only conclude that Lorentz/Fitzgerald contraction is just as contradictory as the now resolved twin paradox used to be. It must be that (18) applies to each single event of any stationary object passing any single point of the train.

Assume a passenger right in the middle of the train whilst it is passing a lamp inside the tunnel. From his perspective the lamp is passing the train, of course. When he sees it pass the front, this passenger will reason: *Given its velocity it will take* Δt *until it passes me*. However, according to (22), this future time span will become compressed to $\Delta t' = \Delta t/\eta$, so when it actually passes him he'll think: *That took less time than I thought, so when it passed the front it must have been closer to me than the front itself, given its velocity.*

That is how Lorentz/Fitzgerald contraction works. It is a paradox by retrospection, just like KTD. It is not about true length but about travelled distance during some time span and the events used for measuring it do not coincide. KTD distorts the perception of this travelled time, hence the travelled distance. Then a fast moving rigid object appears shorter whilst it isn't.

When the lamp actually passes him, it says it will pass the train's rear end after $\Delta t'$ in the lamp's proper time, but the passenger will expect it to occur only after $\Delta t = \Delta t' \cdot \eta$ in *his* proper time. It seems to attempt to pass the train's end before it meets it. That is the prospective paradox. The expected time span will however become compressed to just the right value for the passage and the encounter to coincide, so the paradox will have disappeared when the event actually takes place.

Said otherwise: the event of the lamp passing the passenger has already shifted into the past when the lamp's passage of the rear end takes place and in the passenger's proper time the lamp's elapsed proper time span has become dilated. Since this is a past time span, the passenger now experiences the retrospective paradox of the lamp having passed him before it met him, cf. the twins and (21).

When a passenger measures the passing of the tunnel's entry and exit at a single point within the train, he does not measure this entry or exit passing the train's front or rear end. Those events occur(red) at other points in (his proper) time. He measures the two timestamps of the tunnel openings passing a single point of the train instead of the two positions of these openings at a single point in time. For the observer besides the railway this is similar.

Would the stationary observer measure both ends of the moving object at one single moment in (his proper) time, he would perceive its true physical length and this would exactly equal the physical length of the stationary object. Both events (i.e. the train's front meeting the tunnel exit and the rear end passing the tunnel entry) occur simultaneously.

The passed length at a single point in space equals the product of the time span and the velocity. Due to (inverse) time dilation of the moving time span, this passed length appears shorter than the physical length of the train (as seen from besides the railway) or the tunnel (as perceived from inside the train). Lorentz contraction applies only to the passed length at a single point in space and not to the physical length at a single point in time.

In this way both the stationary and the moving observer perceive all single events in agreement with (18) and they will observe all events in the same temporal order. There will be no conflict about the front's color since they will simultaneously see it getting painted.

In general, the product of a rod's velocity and the time span between the events of its front and rear ends passing an observer is misinterpreted as its length. Instead, it is the distance travelled by the front end since it passed the stationary observer, as it is valid at the moment when the rear end's passage takes place. At that moment KTD has already caused the front's passage to seem longer ago in the stationary observer's proper time than in the rod's proper time, which stretches the travelled distance to the normal length of the rod. The stationary observer measures a smaller time span between the passages of the rod's ends than what the rod itself perceives, so to this observer it seems shortened. He does however not observe both ends at a single point in time so this is not the rod's actual length. The shortening is merely an illusion caused by KTD.

Recapitulation

In an ideal SR scenario, which is perfectly symmetrical, both clocks should be running fully synchronously since both observers agree on both their mutual velocity and their mutual distance, so the time elapsed since their passage equals $\Delta t = d \,/\, v$. An age difference can only arise if some form of asymmetry exists between both observers.

In a collinear SR scenario with three observers, one of them considered stationary and the others moving at different velocities, time dilation by their mutual Lorentz factors yields a contradiction and should therefore be rejected. The longitudinal Doppler factor however renders consistent results for each pair of observers.

During a passage at any transverse distance the transverse Doppler effect applies, which is time dilation by the Lorentz factor.

By realising that it is always *NOW* and that any observer is persistently fixed to the origin of his local frame, one must conclude that *NOW* uninterruptedly resides at this origin. Then the concept of time is only meaningful with respect to *NOW*, and $t = 0$ applies to *NOW* only. Observed time spans are always in the past.

Kinematic time dilation cause any time span on a moving clock to be stretched for the stationary observer, but in his future it will yet become compressed, so the moving clock's ticks approach faster, i.e. in the future it will tick faster. Past ticks are receding faster and then the moving clock ticked slower. *NOW* both clocks show identical values for both observers. KTD works retrospectively and prospectively, but not *NOW* unless there is a bias causing an asymmetry.

Gravitational time dilation will in general be asymmetrical, yielding a bias in the *NOW*s of both observers. The accelerated observer's *NOW* shifts into the inert one's past and the inert one's *NOW* shifts into the accelerated one's future. After B accelerated whilst A remained inert, B lives in A's past and A in B's future. Then A sees B's clock tick slower and B sees A's clock tick faster, causing an ever increasing bias or age difference as long as kinematic time dilation applies. This bias in the proper *NOW*s arose on departure as a result of gravitational (accelerational) time dilation and it enables kinematic time dilation to become asymmetrical without any paradox.

Kinematic time dilation also applies to this bias itself, so for each observer the other one's bias is stretched. This makes $NOW_A = NOW_B$ an unstable equilibrium, since on average time fluctuations become amplified, but due to individual differences in gravitational time dilation both observers will "overtake" one another every now and then, causing the bias to keep fluctuating around zero under normal circumstances.

The clock hypothesis is wrong and superfluous, so it should be left stranded.

Due to the fact that KTD works retrospectively, we cannot ever observe young distant galaxies. We observe them at a proper age of at least 81% of the Hubble time at z ≈ 0.73 or $\beta = \frac{1}{2}$ and the observed proper age of very distant objects approaches the Hubble time. The "youngiverse" can no longer be observed anywhere.

Lorentz/Fitzgerald contraction also appears to contain a contradiction. This discrepancy disappears if one realises it is an illusive paradox by retrospection that in fact takes place in the time domain only and that it does not concern the actual length of a body, but its apparent travelled distance.

Concluding remark: all of this concerns only the interpretation of KTD and Lorentz/Fitzgerald contraction, not the fundamentals behind it. Einstein correctly derived his theory from ascertained truths, such as the Michelson & Morley experiment. But in the fifth paragraph of § 4 of his original publication[1] he applied time dilation to points in time instead of to time spans, which can be seen as the origin of the now resolved interpretation flaw known as the twin paradox.

Hypotheſes non finxi.

References:

1: Albert Einstein: "Zur Elektrodynamik bewegter Körper", Annalen der Physik 17. (1905) pp. 891-921 (original version in German)

2: Aurelius Augustinus Hipponensis (354 - 430 CE), Confessiones 11.14, 11.20

3: Neeleman, M., Prochaska, J.X., Kanekar, N. et al. "A cold, massive, rotating disk galaxy 1.5 billion years after the Big Bang." Nature 581, 269-272 (2020). (https://doi.org/10.1038/s41586-020-2276-y)
(see appendix III) for some calculations on it)

4: Marcel Neeleman: "Disk galaxies grow up so fast". (https://www.mpg.de/14829540/they-grow-up-so-fast-new-observations-show-that-massive-disk-galaxies-formed-exceptionally-early-in-cosmic-history)
(this is in fact the same as ref. 3)

About the author

Henk Reints MSc. (1957) is a Dutch graduated physicist (Eindhoven University of Technology, 1984). After graduation he rolled into a job in automation, where he stayed. But blood is thicker than water, and a few years ago he set himself the goal of understanding the universe conform Sir Isaac Newton's phrase: hypotheſes non fingo, which he interprets as: *I do not fabricate excogitations*.

More of his can be found at Henk-Reints.nl/UQ, which lists documents giving a consistent view of the universe, derived from observations. Some of his findings are:

- according to observed phenomena (i.e. the Subaru Deep Field (SDF) and the SDSS:DR16Q quasar database) the geometry of the universe cannot be anything else than 3-spherical;
- the SDF and SDSS:DR16Q also reveal that the expansion of the universe has always been as linear as can be, straight from the big bang until now; since it is definitely not accelerating, there exists no reason at all to revive what Einstein called his greatest blunder; the hypothesis of dark energy should be rejected;
- Keplerian decline is a hilariously wrong expectation of how galaxies rotate; their velocity profile can be derived using Newtonian mechanics only, without assuming any mysterious dark matter, let alone modified gravity.

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 if I want to explain it, I don't.
Aurelius Augustinus Hipponensis (354 - 430 CE), Confessiones 11.14

HR: time is the succession of events as perceived from one's own perspective.

Appendix I

Simple derivation of the bias in the *NOW*s

Gravitational potential energy:	$V = \frac{-GMm}{r} + V_\infty$	
gravitational potential:	$U = \frac{V}{m} = \frac{-GM}{r}$	
escape velocity:	$v_e = \sqrt{\frac{2GM}{r}}$	$\therefore\ v_e^2 = -2U$
kinetic energy:	$T = \frac{1}{2} mv^2$	
"kinetic potential":	$S = \frac{T}{m} = T = \frac{1}{2} v^2$	$\therefore\ v^2 = 2S$
we set:	$V_\infty = 0,\ \ T_\infty = 0$	
conservation of energy:	$T + V = T_\infty + V_\infty$	$\therefore\ S = -U$
"Schwarzschild factor":	$\xi := \sqrt{1 - \frac{2GM}{rc^2}} = \sqrt{1 - \frac{r_S}{r}}$	$= \sqrt{1 - \frac{v_e^2}{c^2}} = \sqrt{1 + \frac{2U}{c^2}}$
reciprocal Lorentz factor:	γ^{-1}	$= \sqrt{1 - \frac{v^2}{c^2}} = \sqrt{1 - \frac{2S}{c^2}}$
conservation of energy:	$S = -U$	$\therefore\ \sqrt{1 + \frac{2U}{c^2}} = \sqrt{1 - \frac{2S}{c^2}}$
the same is achieved by:	$\xi \equiv \gamma^{-1}$	$\therefore\ \sqrt{1 + \frac{2U}{c^2}} = \sqrt{1 - \frac{2S}{c^2}}$

gravitational length contraction (*g* = gravitated, *p* = proper):
$$L_g = L_p \cdot \xi \qquad L_p = L_g \cdot \xi^{-1}$$

gravitational time dilation (*g* = gravitated, *d* = distant):
$$\Delta t_g = \Delta t_d \cdot \xi \qquad \Delta t_d = \Delta t_g \cdot \xi^{-1}$$

Replacement of ξ with γ^{-1} yields:

accelerational length contraction (*a* = accelerated, *i* = inert):
$$L_a = L_i \cdot \gamma^{-1} \qquad L_i = L_a \cdot \gamma$$

accelerational time dilation (*a* = accelerated, *i* = inert):
$$\Delta t_a = \Delta t_i \cdot \gamma^{-1} \qquad \Delta t_i = \Delta t_a \cdot \gamma$$

The resulting bias in the *NOW*s then equals:

$$\Delta t_{NOW} = \Delta t_i - \Delta t_a = \Delta t_i \cdot \left(1 - \gamma^{-1}\right) = \Delta t_a \cdot (\gamma - 1)$$

Accelerational time dilation causes the duration of the acceleration as measured in the accelerated observer's proper time to become stretched in the inert observer's proper time by the ultimate Lorentz factor (which suggests the acceleration does not have to be uniform).

It also means both observers no longer agree on their mutual distance. At NOW_a the accelerated observer sees the distance the inert observer saw when his proper *NOW* equalled NOW_a, and at NOW_i the inert observer sees the distance the accelerated one will see when his proper *NOW* becomes equal to NOW_i.

Appendix II

The correct Hubble-Lemaître law

Scenario: an object is moving away from us at a constant velocity v with $r = 0$ at $t = 0$. All is as observed in *our* time frame.

This constant velocity is of course in agreement with Newton's law of inertia and we neglect any (intergalactic) gravitational forces. Evidently, Einstein's second postulate also applies: light always moves at velocity c with respect to any observer, independent of the relative velocity of the light source.

No further assumptions are made, which is in agreement with Sir Isaac Newton's phrase: hypotheſes non fingo.

quantity:		**dimensionless:**
time variable:	t	τ
Hubble time:	$t_\mathrm{H} = \frac{1}{H_0} = NOW$	$\tau_\mathrm{H} = 1$
Hubble distance:	$D_\mathrm{H} = ct_\mathrm{H}$	
object's velocity:	v	$\beta = \frac{v}{c}$
object's proper distance:	$r_p(t) = vt$	$\rho_p = \frac{r_p(t)}{D_\mathrm{H}} = \frac{vt}{ct_\mathrm{H}} = \beta \cdot \tau$
at $t = NOW$:	$r_p = vt_\mathrm{H}$	$\boldsymbol{\rho_p} = \beta \cdot \tau_\mathrm{H} = \boldsymbol{\beta}$
photon emitted at:	$t = t_e$	$\tau_e = \frac{t_e}{t_\mathrm{H}}$
proper distance at emission = light travel distance:	$r_\mathrm{L} = vt_e$	$\rho_\mathrm{L} = \frac{r_\mathrm{L}}{D_\mathrm{H}} = \frac{vt_e}{ct_\mathrm{H}} = \beta \cdot \tau_e$
light travel time:	$\Delta t_\mathrm{L} = \frac{r_\mathrm{L}}{c}$	$\boldsymbol{\Delta\tau_\mathrm{L}} = \frac{\Delta t_\mathrm{L}}{t_\mathrm{H}} = \frac{r_\mathrm{L}}{ct_\mathrm{H}} = \frac{r_\mathrm{L}}{D_\mathrm{H}} = \boldsymbol{\rho_\mathrm{L}}$
photon observed at:	$t = NOW = t_\mathrm{H} = t_e + \Delta t_\mathrm{L} = t_e + \frac{r_\mathrm{L}}{c} = t_e(1+\beta)$	
dimensionless:	$\tau_{obs} = \tau_\mathrm{H} = 1 = \tau_e(1+\beta)$	
and of course:	$\tau_{obs} = \tau_e + \Delta\tau_\mathrm{L} \;\therefore\; \tau_e = 1 - \Delta\tau_\mathrm{L}$	
hence:	$(1-\Delta\tau_\mathrm{L})(1+\beta) = 1 \;\therefore\; \Delta\tau_\mathrm{L} + \Delta\tau_\mathrm{L}\beta = \beta$	
yielding:	$\Delta\tau_\mathrm{L} = \rho_\mathrm{L} = \frac{\beta}{1+\beta}$	
to indicate the Hubble flow we use:	β_H instead of β	
which renders the one and only		

correct Hubble-Lemaître law:

$$\Delta\tau_\mathrm{L} = \rho_\mathrm{L} = \frac{\beta_\mathrm{H}}{1+\beta_\mathrm{H}} = \frac{\zeta^2-1}{2\zeta^2} < \frac{1}{2}$$

So the maximum lookback time (in *our* frame) equals half the Hubble time.

For the current (at our $t = NOW$) proper distance we found: $\rho_p = \beta_\mathrm{H}$

All objects emitted their now observed light at most half the Hubble time ago and their current proper distance is always less than the Hubble distance. At emission of the *NOW* observed light the object was much closer to us, at most half the Hubble distance away. Very distant objects were practically halfway through their current proper distance of nearly D_H when they emitted the now observed light and then kept on moving away from us while the light was approaching us, so all we can ever observe is the second half of the age of the universe as perceived in *our* frame. Older light has already passed us and cannot be caught up anymore.

Standard cosmology assumes a way too large light travel distance that would require superluminality. The latter cannot be deduced from ascertained truths such as observed phenomena. Neither has the so-called horizon problem been deduced nor can it be deduced from ascertained truths only, hence it should be firmly rejected.

Please note: this appendix takes no other relativistic effects into account than Einstein's second postulate (the constancy of the speed of light with respect to each observer, independent of any movement of the light source). See (26) for the correct equation that arises when KTD is taken into account.

Appendix III

calculations on ref. 3

Ref. 3 is titled: A cold, massive, rotating disk galaxy 1.5 billion years after the Big Bang. Its redshift is given as:

$$z = 4.2603 \ \therefore \ \zeta = 5.2603 \ \therefore \ \beta = \frac{\zeta^2 - 1}{\zeta^2 + 1} \approx 0.93$$

According to appendix II this β must equal its current proper distance.
If one however wrongly interprets it as the lookback time $\Delta\tau_\mathrm{L}$ it yields an age of:

$$a = 0.07 \times 13.77 \text{ Ga} \approx 0.96 \text{ Ga}.$$

Peebles' equation:

$$\rho_\mathrm{L}(z) = \int_0^z \frac{\mathrm{d}z}{(1+z)\sqrt{\Omega_r(1+z)^4 + \Omega_m(1+z)^3 + \Omega_k(1+z)^2 + \Omega_\Lambda}}$$

with $\Omega_r = 0.266/3454$, $\Omega_m = 0.266$, $\Omega_\Lambda = 0.732$, and Ω_k such that all add up to 1 yields a dimensionless light travel distance of:

$$\rho_\mathrm{L} = 0.889 \ \therefore \ a = 0.111 \times 13.77 \text{ Ga} \approx 1.53 \text{ Ga}$$

which matches the published age that seems in disagreement with the galaxy's apparent adulthood.
According to equation (28) its proper age equals:

$$\alpha_\mathrm{Y} = 1 - \frac{\zeta^2 - 1}{2\zeta^3} = 0.9084 \ \therefore \ a = 0.9084 \times 13.77 \text{ Ga} = 12.5 \text{ Ga}$$

which perfectly matches the observed maturity of this galaxy. Please note that (28) has been derived from ascertained truths only, without making any assumptions. My personal conclusion is that Peebles' equation does not describe reality. It doesn't even come close.

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