Relativity without Formulae - Using Time Traveler's Perspective to Make Time Dilation Calculation Easy and Fun

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Abstract: ***This manuscript aims to simplify time dilation calculation to explain relativity. It is an extension of our previous published paper in IJSR, "Relativity without Complexity"[1] which used a teleportation example to simplify and explain relativity. While simplifying the time dilation function we also repurpose the existing formulae to help in imagination and having fun while drawing important prediction/conclusions.***

Keywords: Relativity, Teleportation, Lorentz Transformation factor, Gravitational Time Dilation, Schwarzschild factor

1. Introduction

Relativity is difficult as we need to deal with speeds near speed of light, gravitation or mass and distances for calculating time Dilations. Further the numbers we deal in calculations are greater than 8th decimal places and lead to infinity. This not only affects free imagination but also leads to dead end at infinite values. Imagination is the core of Relativity and is one of the qualities of Einstein most attributed for, and this paper aims for this freedom of imagination.

We reintroduce our Teleportation example from our previously published paper in IJSR "Relativity without Complexity"[1] for the sake of completeness. It also forms the basis to repurpose the existing time Dilation functions, i.e. Lorentz Transformation Factor from Special theory of Relativity and Gravitational Time Dilation from General Theory of Relativity for greater freedom of imagination. We also see that we do not need these time dilation formulae at all for drawing conclusions about the Universe. It is sufficient to know just that "Time is Relative".

2. Teleportation Example

2.1 "Time is Relative"

So, we now know that Time runs differently for different people. Thus our 1 second can be 2 seconds of other person and vice versa. Let us teleport to a planet where time runs differently and return back to see what we find.

2.2 Time running faster on Earth

Suppose you are a Time Traveller. You teleport to a planet 'X' where 1 second on the planet is 10 years on earth. So you visit that planet find it very difficult to stay there and return back after just 1 second. You see that 10 years have passed on earth. You realise that you have come to the future. The image below illustrates just what you did.

	Earth Time	Time Traveler's time (on Earth)	'X' Planet Time	Time Traveler's Time (on Planet 'X')	Status of Time Traveler
Time	12:00:00	12:00:00	12:00:00	--	Start with same Time for everyone
Year	2023	2023	2023		
Time	12:00:00	--	12:00:01	12:00:01	You teleport to Planet 'X'
Year	2033		2023	2023	
Time	12:00:00	--	12:00:02	12:00:02	Spend just 1 or 2 seconds on "Planet 'X'"
Year	2043		2023	2023	
Time	12:00:00	12:00:03	12:00:03	--	You teleport back to Earth. Congratulations! You are in future.
Year	2053	2023	2023		

Figure 1: Teleportation - Time running faster on Earth

2.3 Time running slower on Earth

You were unable to stay on Planet X for more than a few seconds. Now you prepare yourselves well. You teleport to the Planet 'Y' where your 10 years is just 1 second on earth. You Spend 10 years on the planet, exploring it well. Then Teleport back to earth. You realize that you are back in past on earth. The image below illustrates just what you did.

	Earth Time	Time Traveler's time (on Earth)	Y' Planet Time	Time Traveler's Time (on Planet 'Y')	Status of Time Traveler
Time	12:00:00	12:00:00	12:00:00	--	Start with same Time for everyone
Year	2023	2023	2023		
Time	12:00:01	--	12:00:00	12:00:00	You teleport to Planet 'Y'
Year	2023		2033	2023	
Time	12:00:02	--	12:00:00	12:00:00	You Spend 10 years exploring Planet Y
Year	2023		2043	2033	
Time	12:00:03	12:00:01	12:00:00	--	You teleport back to Earth. Congratulations! You are in past.
Year	2023	2043	2053		

Figure 2: Teleportation - Time running slower on Earth

2.4 Time Travel laws

We can derive following non-exhaustive list of Time Travel laws.

From 2.2 above (and Figure 1):

- As a Time Traveller you come to the future.
- On earth people realise that you have come from the Past.
- You realise that you can travel to any time in future depending on time dilation.
- You realise that Time is running uniformly ahead for everyone, on earth, on planet X and for you even as you teleport.
- Time does not slow down or run fast. It is when you compare the clocks relative to each other that you realise the time is running fast or slow.
- No matter how many times you repeat the experiment, with whatever time dilation, you always teleport to the present time on earth and the planet X.

From 2.3 above (and Figure 2):

- You can travel back in Time.
- People of Earth also realise that you have come from the future. Within a few seconds you spent 10 years on Planet Y.
- You have aged 10 years more than people on earth.
- Whatever time difference you choose, you are unable to go past the starting point.
- Time is still moving uniformly ahead for everyone, for you, for people on earth and on planet Y.

2.5 Paradoxes of Time

Various paradoxes, especially possibility to travel to past, have intrigued great thinkers for decades. Some of which are presented here.

Twin's Paradox: Twin's Paradox is where one twin goes into space and returns back to find that this brother has aged more than him. Traditionally we needed for the Twin to stay longer in space and travel at speeds near speed of light to make the twin age significantly. With teleportation example we do not need to resort to speed of light or the speed of Time Traveller to prove Twin's paradox, in fact the example itself is a form of Twin's paradox. While Twin's paradox raise more doubts, the Teleportation example clears them well.

Grandfather Paradox: The grandfather paradox is where you travel back in time and kill your own grandfather, there is no you. If there is no you, you can't kill your grandfather. It is sometimes taken as an argument against the logical possibility of traveling back in time. However with the teleportation examples we do not need such argument as are never going to travel back in time.

Parallel World theory: As a result of the grandfather paradox, there arose the alternate/parallel history theory. So that now you go back in Time change the past but it does not affect current events, but create another set of events parallel to current events. With the above examples we know that there is no parallel world and time moves uniformly for everyone. This parallel world also arises due to misunderstanding of "sum over histories" in Quantum Physics.

Hawking Party: The world-famous physicist Stephen Hawking threw a party for future time travellers but nobody arrived as he sent the invitation after the party was over. It was a tongue-in-cheek experiment to reinforce his 1992 conjecture that travel into the past is effectively impossible. While a lot of physicists now realise that it is impossible to travel back in time, but they are unable to state it concretely, probably because they still expect there is some scope with quantum mechanics.

The arrow of Time: Stephen Hawking also introduced "The arrow of time" which clearly defines past, present and future. Stephen Hawking proposed three arrows of time: psychological time, thermodynamic or entropic time, and cosmological time. As all three arrows of time move forward, we cannot travel to the past. Our example clearly shows that the arrow of time moves forward for everyone.

The teleportation example explained well the Time Travel laws for both traveling to past and future. However, does it stand the test of physics and mathematics? We know that time slows down with increasing speed of the Time Traveller or when the Time Traveller is under heavy gravity. There are two different mathematical formulae for the speed of time traveller and when the Time Traveller is under heavy gravity. We deal with these two formulae in the next two sections.

3. Reverse Lorentz Transformation formula

We saw our Teleportation example gives us Time Travel laws including traveling to past. Our Teleportation example also directly raises the question how fast are you travelling as a Time Traveller if Earth's 10 years is 1 second for you? When we say our 10 years will be 1 second on earth we are indirectly referring to Time Dilation.

3.1 Lorentz Transformation Factor

The answer to how fast the Time Traveller is traveling lies in Lorentz Transformation Factor. It gives us the time dilation factor based on the speed of Time Traveller compared to speed of light. Lorentz Transformation Formula is given by below formula

$$\lambda = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

Where,
λ is Time Dilation factor or Lorentz Factor
v is speed of time traveller
c is speed of light

Following steps lead to our **Reverse Lorentz Transformation Factor** :

$$\lambda^2 = \frac{1}{1-\frac{v^2}{c^2}} \quad \textbf{step 1} \tag{2}$$

$$1-\frac{v^2}{c^2} = \frac{1}{\lambda^2} \quad \textbf{step 2} \tag{3}$$

$$-\frac{v^2}{c^2} = \frac{1}{\lambda^2}-1 \quad \textbf{step 3} \tag{4}$$

$$\frac{v^2}{c^2} = 1-\frac{1}{\lambda^2} \quad \textbf{step 4} \tag{5}$$

$$\frac{v}{c} = \sqrt{1-\frac{1}{\lambda^2}} \quad \textbf{final formula} \tag{6}$$

3.2 Reverse Lorentz Transformation Factor - advantages

We just derived the Reverse Lorentz Transformation Factor in equation (6). The following makes this formula interesting and fun to use:

- The result we get is a ratio of speed of time traveller to the speed of light.
- When we multiply it with actual speed of light we get actual speed of Time Traveller.
- When we multiply the result with 100 we get percentage of speed of Time Traveller to Speed of light, which is easy to understand.
- The calculation involves only a single variable that we now intuitively know as Time Dilation from the Teleportation example.
- We can choose any suitable integer value for time dilation making it easier to solve mentally for most part.
- While with Lorentz Transformation formula we reached a dead end with values close to speed of light, with this formula we have freedom to choose any integer value from 1 to infinity.
- We immediately realise by looking at the formula that choosing zero as time dilation does not make sense. Our 1 second cannot be 0 second for other person as time always moves forward.
- With original Lorentz Transformation formula we get results that are usually so insignificant that we need further calculations by spreading the value over number of years to make it usable. That is also one of the reasons why Relativity is considered so difficult. This is not the case with the new formula.
- The Time dilation we deal with is in number of seconds, which we can easily convert for any number of years.

3.3 Examples using Reverse Lorentz Transformation Factor

Let us see how fast you are travelling as a Time Traveller travelling for various values of Time Dilation

Example 1: when earth time is 2 seconds for every 1 second for you on a planet you are traveling at 86.6% speed of light. We see that by putting the value of 2 in λ as below:

$$\frac{v}{c} = \sqrt{1-\frac{1}{2^2}} = \sqrt{1-\frac{1}{4}} = \sqrt{0.75} \tag{7}$$

$\frac{v}{c} = 0.866$ OR 86.6 % speed of light (7) contd.

Multiplying the result with actual speed of light (299792 km/s) we get the actual speed of the time traveller i.e. 259619.872 Km/s and multiplying it with 100 gives us 86.6% of speed of light.

Example 2: When earth time is 1000 seconds (around. 17 minutes) for every 1 second for you, you are travelling at 99.99995% speed of light.

$$\frac{v}{c} = \sqrt{1-\frac{1}{1000^2}} = 0.9999995 \tag{8}$$

Example 3: When earth time is 30000000 seconds (less than 1 years) for every 1 second for you we get 99.9999999998 % speed of light.

$$\frac{v}{c} = \sqrt{1-\frac{1}{30000000^2}} = 0.99999999999999994 \tag{9}$$

The original Lorentz Transformation Factor leads to infinity and dead end at speeds near speed of light. With reverse Lorentz Transformation Factor we are free to choose any number from infinite integer values. We get results that are not infinity, but we realise that going on any farther with this formula does not make any practical sense.

It may be noted that Reverse Lorentz Transformation factor may not be confused with Inverse Lorentz Transformation factor, which still uses speed of time traveller to get Lorentz factor but from another frame of reference. Our Reverse Time Lorentz Transformation factor uses time dilation to get speed of Time Traveller.

4. Reverse Gravitational Time Dilation

We know that Time slows down when we travel near speed of light and when we are near higher gravity. We already calculated the speed of our Time Traveller travelling from time dilation. Now let us find the gravity from Gravitational Time Dilation formula.

4.1 Schwarzschild factor for Gravitational Time Dilation

The gravitational time dilation formula was given by Schwarzschild and is also known as Schwartzchild factor similar to Lorentz factor. It is given by the formula:

$$\lambda = \frac{1}{\sqrt{1-\frac{2GM}{rc^2}}} \tag{10}$$

Where,
λ is Time Dilation factor or Schwartzschild Factor
M is Mass of the object affecting gravitation
r is radius or distance from the center of the Mass
c is speed of light = 299,792,458 m/s
G is Gravitational constant = 6.6542 x 10^{-11} Nm^2/kg^2

Following steps lead to our **Reverse Schwartzschild Factor** or **Reverse Gravitational Time Dilation factor** which are very similar to our previous example with Reverse Lorentz Factor:

$$\lambda^2 = \frac{1}{1-\frac{2GM}{rc^2}} \qquad \textbf{step 1} \tag{11}$$

$$1-\frac{2GM}{rc^2} = \frac{1}{\lambda^2} \qquad \textbf{step 2} \tag{12}$$

$$-\frac{2GM}{rc^2} = \frac{1}{\lambda^2} - 1 \qquad \textbf{step 3} \tag{13}$$

$$\frac{2GM}{rc^2} = 1-\frac{1}{\lambda^2} \qquad \textbf{step 4} \tag{14}$$

$$\frac{M}{r} = (1-\frac{1}{\lambda^2}) \times \frac{c^2}{2G} \qquad \textbf{step 5} \tag{15}$$

$$\frac{M}{r} = (1-\frac{1}{\lambda^2}) \times \frac{299792458^2}{2\times(6.6742\times10^{-11})}$$

As we already know values for c and G **step 6** **(16)**

$$\frac{M}{r} = (1-\frac{1}{\lambda^2}) \times 6.733055\times10^{26} \quad \textbf{final formula} \tag{17}$$

4.2 Reverse Gravitational Time dilation - advantages

We derived the Reverse Schwarzschild formula or Reverse Gravitational Time Dilation formula in equation (16). Like Reverse Lorentz Transformation formula this is also a very interesting and fun formula :

- The result we get is a ratio of Mass of object causing gravitation to the distance from the centre of the object.
- Interestingly the result is a ratio of Mass in kgs for 1 meter radius. That is what a common person can easily understand.
- It involves only a single variable that we now intuitively know as Time Dilation from the Teleportation example.
- We can choose any suitable integer value for time dilation making it easier to solve mentally for most part.
- While with Gravitational Time Dilation formula we reached a dead end with infinite Mass or when radius is zero, like in a black hole. But with our derived formula we have freedom to choose any integer value from 1 to infinity for time dilation.
- We realise by looking at the formula that choosing zero as time dilation does not make sense. Our 1 second cannot be 0 second for other person as time always moves forward.
- The Time dilation we deal with is in number of seconds, which we can easily convert for any number of years.
- More interesting is that with the result we can get Mass from Radius or Radius from Mass of the object (sun or star or planet)
- From the result i.e. ratio of M/r we can chose radius or distance from the centre of the object to be any integer value to simplify calculations.
- The integer we choose can be imaginary and may not be related to any specific star. This is helpful when we think in terms of black holes.
- From our chosen Radius or Mass, we can calculate small g or Gravity which is understood well by common people.

$$g = \frac{GM}{r^2} \tag{18}$$

- With both Reverse Lorentz formula and Reverse Gravitational Time dilation formula, for any value of time dilation we can find equivalent speed of the Time Traveller or ratio of Mass and Radius of the Planet he is on.

4.3 Examples using Reverse Gravitational Time dilation Formula

We use the same values in our example as for Reverse Lorentz formula.

Example 1: when earth time is 2 seconds for every 1 second for we get a result as get 5.0498 x 10^{26}kg for 1 meter radius. So you are on a planet with mass and depending on the distance in meter of your chosing.

$$\frac{M}{r} = (1-\frac{1}{2^2}) \times 6.733055\times10^{26} \tag{19}$$

$$= \frac{5.0498\times10^{26}\,kg}{1meter} \qquad \text{(19) contd}$$

Example 2 : when earth time is 30000000 seconds (less than one year) for every 1 second for we get a result as get 6.7331 x 10^{26}kg for 1 meter radius. So you are on a planet with mass and depending on the distance in meter of your choosing.

$$\frac{M}{r} = (1-\frac{1}{30000000^2}) \times 6.733055\times10^{26} \tag{20}$$

$$= \frac{6.7331\times10^{26}\,kg}{1meter} \qquad \text{(20) contd}$$

We see that we can choose a value of less than a metre in the ratio of Mass/distance, which is helpful for trying out values for black holes which has intrigued physicists. We had always assumed the radius of a black hole to be 0 which will give us infinite mass.

5. Results – answering difficult questions

We saw that our example solves many problems that relativity can solve without actually resorting to any formulae. We did used the reverse Time Dilation functions for speed and Mass and Gravity, we realised that unlike their original formula they do not end in infinity, but we realise that going on any further with the formula seems meaning less. The formula were thus able to give a valuable insight about the dead end with infinity in original equations. With or without the equations, the Teleportation example still stands good. So, can the new insight or the teleportation example solve the yet unsolved questions. Let us see some application of our newly discovered tools.

Closed time-like curve (CTC): Closed-Time-Like-Curve experiments suggests that somehow you travel faster than light in a cyclic manner and meet your past. However, we see from our examples that it is not possible to travel in the past even with CTC. Our earlier paper "Relativity without Complexity"[1] which also dealt with faster than light was also based on the teleportation example also suggest that even with faster than light travel we cannot travel in past. It is just gives us an optical illusion of things going in reverse direction.

Quantum physics: Quantum physics though understood so well, has not yet helped us understand time at quantum level. The "sum over histories" and "many worlds" interpretation of leads to people assuming that there are multiple timelines or parallel worlds. But people don't realise that all these worlds are described by probability, which collapses as soon as one tries to observe the phenomenon. To say it straight the quantum particles are in multiple states at the same time but not in past, present and future. Interpreting sum over histories as past, present and future will only mislead us.

Another property of Quantum physics puts an end to this past, present and future debate. Quantum Entanglement. When two particles are entangled they share their states with each other. When they placed away from each other and we observe the state of one particle, we immediately know the state of the other particle. Quantum Entanglement works even when we keep one of the particles in any part of the universe. It works even in a time dilated system eg. where 10 years of the planet is just 1 second of earth. The results are instantaneous and not in past, present and future.

Unified theory of gravity: Unsuccessful efforts are being made to unify the two established theory of quantum theory at micro level and Theory of Relativity at macro level. However, we now know that time runs in forward direction, there is no separate past or future than present. We saw that both quantum mechanics and theory of relativity agree on same. Our calculations time dilation suggests that we need another formula that is more precise than speed of light. The answer lies probably is not much far with our new tools.

Blackhole: With our new mathematical tools, understanding of quantum mechanics and moving towards unified theory of gravity the answer to time at black hole is not much farther. We know that time always moves forward and does not stop. We know that black hole has a finite life. Then assuming time becoming infinite at singularity is not logical. Time becoming equally infinite for a black hole and supermassive black hole is also not logical. We already handled infinity multiple times in this paper. So we can easily assume that 1 second on a black hole can be 1 million years for us. The same can be 100 million year or 1000 million years for another black hole. With our new tool, infinite is not an answer time to black hole.

6. Conclusion

The new time dilation formulae are both fun and easy to use, and can be done mentally for most part.

The new formulae do not entirely fail at infinite values, like their older counterparts, only that we realise it is meaningless to go on any further. That we realise we need another more precise tool that is not based on speed of light.

For the first time since Einstein, we will be able to easily find both Speed of the Time Traveller or Gravity or both for same value of Time Dilation.

We now have levels of abstraction of Relativity that can be taught to kids in schools which was a domain of only physicists. We can teach kids Relativity using only Teleportation example that says "Time is Relative". For higher classes we can introduce the Reverse Lorentz Transformation Factor, the Reverse Schwarzschild factor.

For all its advantages and future applications it is an indispensable tool for physicists.

7. Future Scope

As pointed out these formulae have just been introduced and there is lot of future scope:

- There is scope for finding another formula which is probably not based on speed of light. The simplest solution without any formula is to send atomic clocks in heavily time dilated system and get actual time dilation.
- There is scope for understanding time in much better manner. This paper is opens up new possibilities and areas to explore.
- As the formulae have just been introduced, there is a lot of scope and domains where it can be applicable and only time can tell what new it brings out.
- Beyond this paper, efforts need to be put to make it widely publicized, so that it reaches all physicists and students who have lot of imagination and drive to discover new things.
- This paper does not replace the original Lorentz and Schwarzschild formula, but is a great addition to it.

- Whereas the original Lorentz and Schwarzschild formula lean more towards actual speeds and gravity, the new formula gives a very high degree of freedom to choose imaginary values.
- While these new approach helps to understand time much better, we have not yet completely explored it's utility for understanding time at black hole or under quantum mechanics or the unified theory of gravity.

References

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