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Can We Use the Earth's Rotation to Do an Experiment to Prove the Time Dilation of Special Theory of Relativity?

Salman Mahmud*

Student of BIAM Model School and College, Bogura, Bangladesh.

***Corresponding Author:** **Salman Mahmud,** Student of BIAM Model School and College, Bogura, Bangladesh.*

Abstract: *According to the special theory of relativity, time dilation is a difference in the elapsed time measured by two observers, either due to a velocity difference relative to each other. If two observers move in different speed, then the observer who will move fast his time will be slower than the other observer. As the earth is spherical and moves on its own axis, that's why the speed of of every point on earth's surface is not same.We know, the speed of any point on earth's surface depends on the vertical distance between the point and the axis. If we keep two atomic clocks on two different points on earth's surface where the speed of those two points are different and start the clocks at the same time and again stop the clocks at the same time, then there will be a time difference in those two clocks according to time dilation. If we get the accurate time difference described by the time dilation formula, then it will be the easiest experiment to verify the time dilation.*

Keywords: *Time dilation, Special Relativity, rotation of earth, earth's speed.*

1. Introduction

Time dilation is the most interesting part of special theory of relativity. Time dilation has been verified by so many experiments. But here we will discuss about a simple and easy experiment where we will use the rotation of earth. The earth rotates once in about 24 hours with respect to sun, but once every 23 hours, 56 minutes and 4 seconds with respect to other, distant, stars. Earth's rotation is slowing slightly with time. But here we will use 24 hours as the time of a complete rotation of earth on its own axis.

In every 24 hours, every point on earth's surface overcomes a circular path. The length of every circular path depends on the vertical distance between every point and the axis of earth. The vertical distance between the axis and any point on earth's surface is the radius of the circular path overcome by that point. If we divide the length of any circular path overcome by any point on earth's surface by 24 hours, we will get the speed of that point. According to the special theory of relativity, time dilation is a difference in the elapsed time measured by two observers, either due to a velocity difference relative to each other. If two observers move in different speed, then the observer who will move fast his time will be slower than the other observer. The time difference between them will depend on the velocity difference between them. . If we keep two atomic clocks on two different points on earth's surface where the speed of those two points are different and start the clocks at the same time and again stop the clocks at the same time, then there will be a time difference in those two clocks according to time dilation. If we get the accurate time difference described by the time dilation formula, then it will be the easiest experiment to verify the time dilation.

2. Calculating the Speed of any Point on Earth's Surface

Look at the figure below.

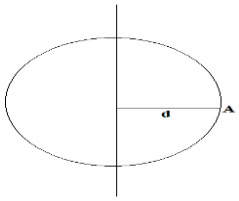

Figure1. *A is any point on earth's surface and d km is the vertical distance between the point and axis of earth.*

The length of the circular path overcome by the point A in one day will be $= 2\pi d$ km

So the speed of point A $= \frac{2\pi d}{24}$ km/h $= \frac{2\pi d}{24\times3600}$ km/s

3. The Process to do the Experiment

The process of the experiment is as follows:

1.First of all we have to select two points on earth's surface where the velocity of those two points are different.

2. Then we have to place two atomic clocks in the middle of those two points.

3.We have to start the clocks at the same time.

4.Then the two clocks have to be taken to those two points at the same speed.

5. We have to artificially keep the temperature, air pressure, gravitational acceleration etc. same for both points. Only the speed of those points will be different.

6.After a few days, the two clocks have to be taken to the midpoint of those two points.

7.At last we have to stop those two atomic clocks at the same time.

After finishing the above process, we will get a time difference between the two atomic clocks. If we get the time difference according to the time dilation formula, then time dilation will be easily verified.

Suppose, the selected two different points on earth's surface are A and B. The vertical distances between these two points and the axis of earth are d_1 and d_2 respectively. Then velocity difference between these two points will be

$$\Delta v = \left| \frac{2\pi d_1}{86400} - \frac{2\pi d_2}{86400} \right| \text{ km/s}$$

According to the special theory of relativity, if the speed difference between two observers is *v*, then the time of the observer whose speed is slow than the other observer will be

$$t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Here, t_0 is the time of the other observer who is faster than the other. Now the time difference of these two observers will be

$$\Delta T = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} - t_0$$

Similarly the time difference of those atomic clocks will be

$$\Delta T_C = \frac{t_0}{\sqrt{1-\frac{(\Delta v)^2}{c^2}}} - t_0$$

In this process we can use the earth's rotation to prove the time dilation of special theory of relativity.

4. Conclusion

Time dilation is the most important part of special theory of relativity. We can easily use the rotation of earth to prove this. We have to apply the above process very carefully. The speed of earth is very slow comparing to the speed of light. That's why after a few days, the time difference between the two clocks will be a few nanoseconds. So, we have to do all the measurements carefully.

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AUTHOR'S BIOGRAPHY

Salman Mahmud, is an undergraduate student of BIAM Model school and College, Bogura, Bangladesh. His core research interest is in modern physics and pure mathematics. But he is interested in all the sectors of science. He has contributed in so many researches.

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