Negative Time Dilation

Patrick Richard

Introduction

Time travel is something that man has always speculated about. When Albert Einstein published his two Theories of Relativity, science fiction writers got excited about the concept of time dilation. Was non-forward time travel really possible? While it has not been scientifically proven that negative time dilation is possible, it has not been proven impossible. This paper examines the implications of time travel by negative time dilation and the way in which the laws of physics dictate time travel.

Laws of Thermodynamics

First we will look at the implications of the laws of thermodynamics. They play a part in dictating what is possible in a system where negative time dilation occurs.

The first law of dynamics states that e*nergy cannot be created or destroyed.* This can result in one conclusion. *If a particle travels "back in time" it does not duplicate itself. It also cannot co-exist with the older version of itself.* This means that if an object travels "back in time" it replaces all of the particles and energy that make it up. We will examine the implications of this in more detail later.

The second law of thermodynamics states that *heat flows from hot to cold, and not in the other direction.* More fundamentally, it sets the direction that time moves in. Many processes can only occur moving towards one state as time progresses. However, when a particle travels through time in reverse, the processes reverse with time. So the second law is relative. A process that only occurs in one direction is based on time, and from a frame of reference moving through time in reverse relative to the process it will appear to be occurring in reverse.

Light and Time

The speed of light is relativistically invariant; it always moves at one speed viewed from any frame of reference. Therefore, it can be analogized to the flow of time. From a fixed frame of reference, time in this frame of reference will always appear to move at one rate. Time will never appear to move more slowly or quickly, regardless of how time changes relative to another frame of reference. This is very important in time travel. To see why, we picture Observer A standing in a time machine in 2009 A.D., travelling back to the year 4000 B.C., around the time when civilization started. Inside the time machine, everything seems normal. He checks his watch, and it is moving at a normal speed. He clearly is not getting younger. But as he looks outside, he sees clocks moving backwards, human-made things being disassembled, and things appear to be falling upwards. Finally he arrives at 4000 B.C. Time starts moving forwards in the outside world at a normal rate; however, the world has become very primitive. What is very important to realize is that Observer A is still in the year 2009 A.D.; only his surroundings are in the year 4000B.C.

When a process occurs, such as a clock ticking or a biological process, something is causing it. Usually it is caused by something relativistically invariant, such as the movement of light or other movement caused by electromagnetic, gravitational, or nuclear forces. When the speed of light changes relative to the process as observed from an outside frame of reference, as a result the whole process changes speed as observed from the outside frame of reference. The observed speed of the process is based on the observed speed of light relative to the process. A change in the apparent speed of light relative to the process is caused by the process moving relative to the observer, or by the process occurring in an area of higher gravity or acceleration.

Going back to our previous example, we remember that Observer A continues to move forward through time. However, he is observing a process occurring in reverse; he is observing the world minus him as a process occurring backwards.

For a process to occur in reverse, time dilation relative to a standard reference, such as a time traveller, must be negative. For time dilation to be negative, the physical constituents of the process must appear to be moving faster than the speed of light from the standard frame of reference. This paper does not examine in detail the possible causes of this, but looking at it from a time traveller's perspective, he/she must see the outside world to be moving faster than the speed of light. Relativistically invariant factors will then appear to be moving in reverse relative to the rest of the universe, so all of the affects of these factors will appear to move in reverse.

Relationship Between Unsynchronized Times

We need a mathematical model to represent time travel. More specifically we need a relationship between the times of two objects that are moving through time at a different rate. The first equation is quite simple.

$$t_1' = rt_2'$$

where t_1' is the rate at which the object 1 is moving at, t_2' is the rate at which object 2 is moving at, and r is the time dilation of object 1 as observed from object 2.

However, the time dilation factor might be changing.

$$r = r_i t_2 + r' t_2$$

where r_i is the initial value of r, r' is the average rate at which r is changing at and t_2 is the amount of time that r is changing for.

Object 2 will observe its own, as well as object 1's processes as a function of time.

$t_1 = rt_2$

$t_1 = r_i t_2 + r' t_2^2$

where t_1 is the amount of time that has gone by for object 1, and t_2 is the amount of time that has gone by for object 2.

When a time traveller is “travelling back in time,” the outside time will be represented by t_1 while his/her time will be represented by t_2. t_2’ will always be 1.

Time Paradoxes

There are many paradoxes associated with time travel, such as the grandfather paradox. For example, if a person goes back in time and kills his grandfather, then he can never be born. However, if he is not born, then he cannot travel back in time, so then his grandfather will survive. But if his grandfather survives, then he will travel back in time to kill his grandfather. There must be a resolution.

As we recall, the first law of thermodynamics states that energy cannot be created or destroyed. Also, we must consider that when an observer “travels back in time” he/she is really observing the universe around it traveling through time in reverse. So if an observer “travels back in time”, the observer itself does not reverse its processes. The rest of the universe will, but the observer will not be included. This means that *if an observer observers the universe to have a negative time dilation, the reversed processes of the universe will differ from what they were when they occurred forward. This change will result by the processes occurring during a different state of the observer.*

So back to our example of Observer A travelling to 4000 BC. Say we were to represent different parts of the evolution of the universe as functions of time. As we increase the time, the universe evolves further. Under normal circumstances, if we decrease the time, the universe becomes less evolved. However, when Observer A is “travelling”, we must first set all values so that their initial value is at the point when Observer A departs from the timeline of the rest of the universe. Then, functions that model all of the pieces and particles that comprise observer A will move forward through time. Everything else will move backwards through time. Observer A will still interact with the rest of the universe, but he will not interact in the same way as he would have in the past. As a result, the universe will be different than the history that observer A will be familiar with. His history is still his history, but it is not shared with the rest of the universe.

So now we can look at what happens with time paradoxes. Observer A can never interact with his own past. The universe has changed, and all energy that he is comprised of will now exist in him; it does not exist in his surroundings. Say that the day before he embarked on his journey he decided that he would eat a 6000 year old preserved bird. This bird will now be part of him (in his digestive system) and will not exist in the surrounding universe, even in 4000BC. There is none of his past around him; it is impossible for him to affect his past. Now, say that he jumps forward through time. He will notice that he has changed history, for example he may have destroyed humanity (or even just have left a footprint), but this still does not in any way change his own history. His history is the same one that he had before his journey, but this does not match the history of the universe. He is the same person as he was when he left, only slightly traumatised.

Another effect of observer A travelling to 4000BC is that he will change history from before 4000BC. Timelines can be seen as reversible; if observer A causes something to happen at any point in his travel, the laws of physics must still be followed. That means that the initial conditions of the universe must change to allow the future to change.

Conclusion

Here we have seen the true nature of time travel by negative time dilation. It is not as it is portrayed in science fiction. If a being travels back in time, it will be able to change the history of the universe, but it can not change its own history. This eliminates time paradoxes caused by time loops. The being also changes history as it travels backwards, not just as it travels forwards. This is caused by the being exerting different forces on the universe as it travels back then when it was traveling forwards.

This is not to say that time travel is as depicted in science fiction is not impossible. Just as our discovery of time dilation a century ago, which at the time seemed like an impossible concept, we may yet discover methods of time travel other than through time dilation, methods that allow time loops and paradoxes. However, it will not be through time dilation as we know it.