TIME DILATION IN RELATIVITY

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The following is an attempt to explain that time dilation in relativity is an apparent phenomenon only, i.e., when one frame moves relative to another at a constant speed, it only appears that its clock runs slower than the other. In the first (simple) case, the box remains stationary. In the second, it moves horizontally at speed = 0.5c. By having lights flash simultaneously at the ends of the box, the "photos" that reach the observers (at positions = 0 in each frame) record simultaneous positions for comparison to determine the "true" box length because both photos are taken at the same time, even though they do not reach the observers simultaneously. Each photo records the light flash and the corresponding positions and times in both frames when the flash occurred. The conclusion drawn from this analysis is that, whether or not reference frames are moving relative to one another, time does not vary – any such variation is apparent only.

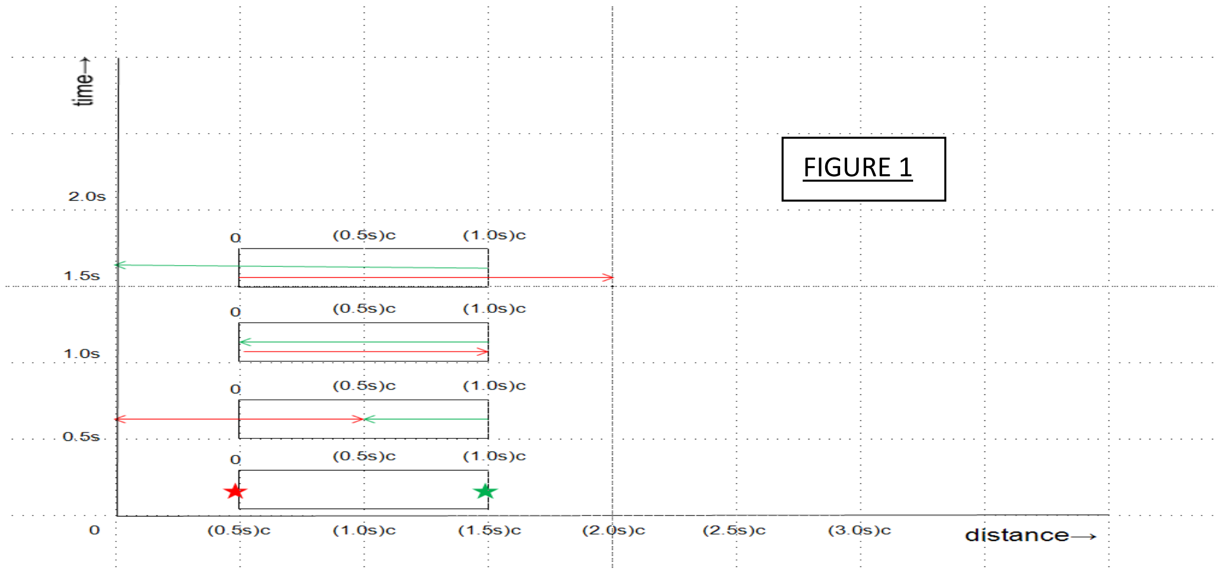
INTRODUCTION

To set up the analysis, consider a simple, one-dimensional case where one frame (a box of fixed length = [1.0s]c)[1] is aligned along the stationary axis of another frame. Initially, both frames have synchronized clocks that run at the same rate. These synchronized clocks are located all along the length of both frames, i.e., all along the box and the axis; and, within each frame, they record the same time everywhere, as they are synchronized. The box has a red light at one end and a green at the other, i.e., at positions = 0 and (1.0s)c in the box frame. Both flash simultaneously at time = 0 (same in both frames) when the box is aligned with positions (0.5s)c (red) and (1.5s)c (green) along the axial frame. This is illustrated by the bottom box in Figure 1.

SIMPLE CASE – STATIONARY BOX

In this simple case (box stationary) in Figure 1, a red and green light flash simultaneously in the box at time = 0 (both frames). Since this is a one-dimensional case, the light propagates only horizontally, but in both directions. The observer in the box at position = 0 immediately sees the red flash in his frame, but at position = (0.5s)c in the axial frame. After 0.5s (in both frames), the red flash reaches the observer at position = 0 in the axial frame, showing him time = 0 and position = 0 from the box, but position = (0.5s)c in his frame. At time = 1.0s (both frames), the green flash reaches the observer at position = 0 in the box, showing position = (1.0s)c in his frame, but position = (1.5s)c in the axial frame. Finally, at time = 1.5s (both frames), the green flash reaches the observer at position = 0 in the axial frame, showing position = (1.0s)c in the box and (1.5s)c in his frame. From the axial frame, the two lights appear to have flashed across a distance of (1.5s)c – (0.5s)c = (1.0s)c in 1.5s – 0.5s = 1.0s. Also in the axial frame, the lights appear to have flashed across a distance of (1.0s)c – 0 = (1.0s)c as measured in box distance. From the box, the lights appear to have flashed across a distance of (1.0s)c – 0 = (1.0s)c in 1.0s – 0 = 1.0s in his frame, but (1.5s)c – (0.5s)c = (1.0s)c in the axial frame. For both the axial and box observers, the distance and time between the two flashes in either frame are (1.0s)c and 1.0s, corresponding to light traveling at speed = c in both frames. This is the expected, trivial result.

[1] For consistency, I specify time with its unit of seconds ("s") such that a product of time and light speed ([s] x [m/s] = m) is always clearly recognizable as length.



NOT SO SIMPLE CASE – MOVING BOX

Consider the same situation, but now with the box moving horizontally at constant speed = (0.5s)c, as illustrated in Figure 2. Start with respect to the box frame, since this is where the lights are. When they flash at time = 0, their positions in both frames are as before. However, now 1.0s rather than just 0.5s must elapse before the red flash reaches the axial observer at position = 0. It provides the same information as before, i.e., box position = 0 and axial position = (0.5s)c. Another 2.0s must elapse before the green flash reaches the axial observer at position = 0, i.e., at time = 3.0s rather than 1.5s as before. Again, the same information is provided, i.e., box position = (1.0s)c and axial position = (1.5s)c when time = 0 in both frames. So, what has changed – for the box observer, the following.

The time and distance between the two flashes are again 1.0s – 0 = 1.0s and (1.0s)c – 0 = (1.0s)c in his frame. The distance is (1.5s)c – (0.5s)c = (1.0s)c in the axial frame, both recorded simultaneously when the axial clock was at time = 0. However, when he sees his green flash, he is aligned with the position = (1.0s)c in the axial frame.. Thus, while he knows the box length as measured in the axial frame is the same as in his (at the simultaneous time = 0, the box covered distance = [1.5s]c – [0.5s]c = [1.0s]c along the axis), he measures the speed of light in the axial frame to be only half the speed in his, since the distance traversed across the axis <u>appears to be</u> only (0.5s)c. Yet 1.0s of time elapsed.

Now, consider the axial observer at position = 0. He sees the flashes 3.0s – 1.0s = 2.0s apart in his frame, but knows from the flashes that the box covers a distance = (1.0s)c – 0 = (1.0s)c in its own frame since both of these positions were recorded when the box clock time = 0 (simultaneous). Thus, the axial observer measures the speed of light in the box frame to be (1.0s)c/2.0s = 0.5c (the same as what the box observer measured for the axial frame). However, both observers, "knowing" the speed of light is a constant = c everywhere, can only conclude as follows. In the opposite frame, it has to take 1.0s to traverse a distance of (1.0s)c, just as in my own frame. Therefore, if my clock registers twice as much time to cover this same distance, my time must be running twice as fast as the time in the other frame. The box observer measured 1.0s to traverse (0.5s)c along the axis, which would require only 0.5s in the axial frame. Therefore, his "second" must equal the axial frame's "half-second." Meanwhile, the axial observer measured 2.0s to traverse (1.0s)c along the box length, which would require 1.0s in the box frame. Therefore, his "two seconds" must equal the box frame's "second."

Thus both observers see the same apparent time dilation, namely their (stationary) clock running twice as fast as the (moving) one in the other frame (see Table 1). However, in reality neither the box length nor the rate of time passage differs in either frame, even when there is relative motion.

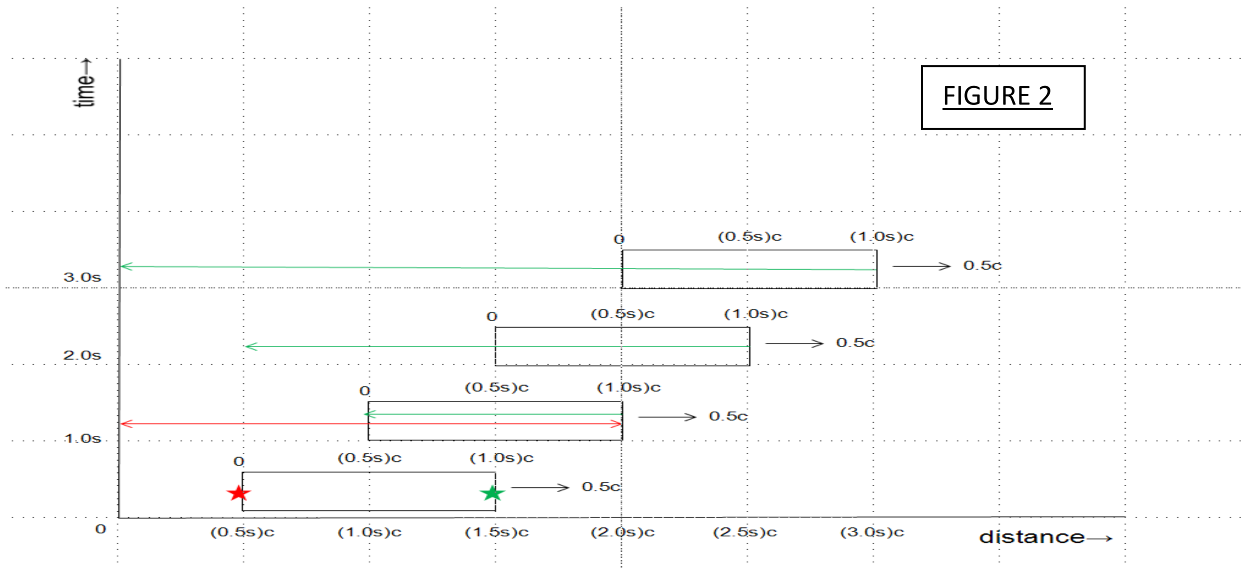


FIGURE 2

Frame		Red Flash		Green Flash		Apparent			Time Dilation
Ref	Obs	Position	Time	Position	Time	Distance	Time	Speed	
Box	Axis	(0.5s)c	0	(1.0s)c	1.0s	(0.5s)c	1.0s	0.5c	c/(c/2) = 2
Axis	Box	0	1.0s	(1.0s)c	3.0s	(1.0s)c	2.0s		

TABLE 1.

CONCLUSION

This paper presented a relatively simple, minimally calculational, exercise in an attempt to understand the reputed phenomenon of time dilation (and, by analogy, length contraction) associated with constantly moving frames of reference at near-light speeds (e.g., > 0.1c). Through the use of what I hope was a fairly straightforward example, it seems to me that the reputed phenomenon is only an "optical illusion," an appearance of time dilation, but not an actual change in the rate at which time passes. While I am certain others have reached similar conclusions, I hopefully have provided a somewhat different, and hopefully new, perspective.[2]

[2] One such approach is that of Steven Bryant's Modern Classical Mechanics, "a new, intuitive, model that yields better than 100 times the accuracy of the Einstein-Lorentz equations in several experiments including Michelson-Morley and Ives-Stillwell! Because it distinguishes between Length and Wavelength, its theoretical explanations avoid non-intuitive concepts like time dilation, length contraction, and the twin paradox; each of which are required by Relativity theory." In fact, what I present here as an "appearance" of time dilation, he presents as a Doppler Shift rather than any actual change in length or time. *(http://www.relativitychallenge.com/archives/823)*

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To set up the analysis, consider a simple, one-dimensional case where one frame (a box of fixed length = [1.0s]c) is aligned along the stationary axis of another frame.

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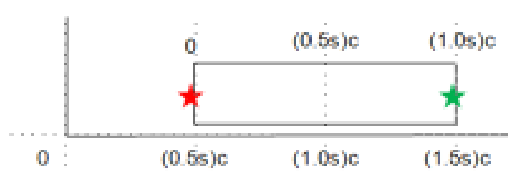
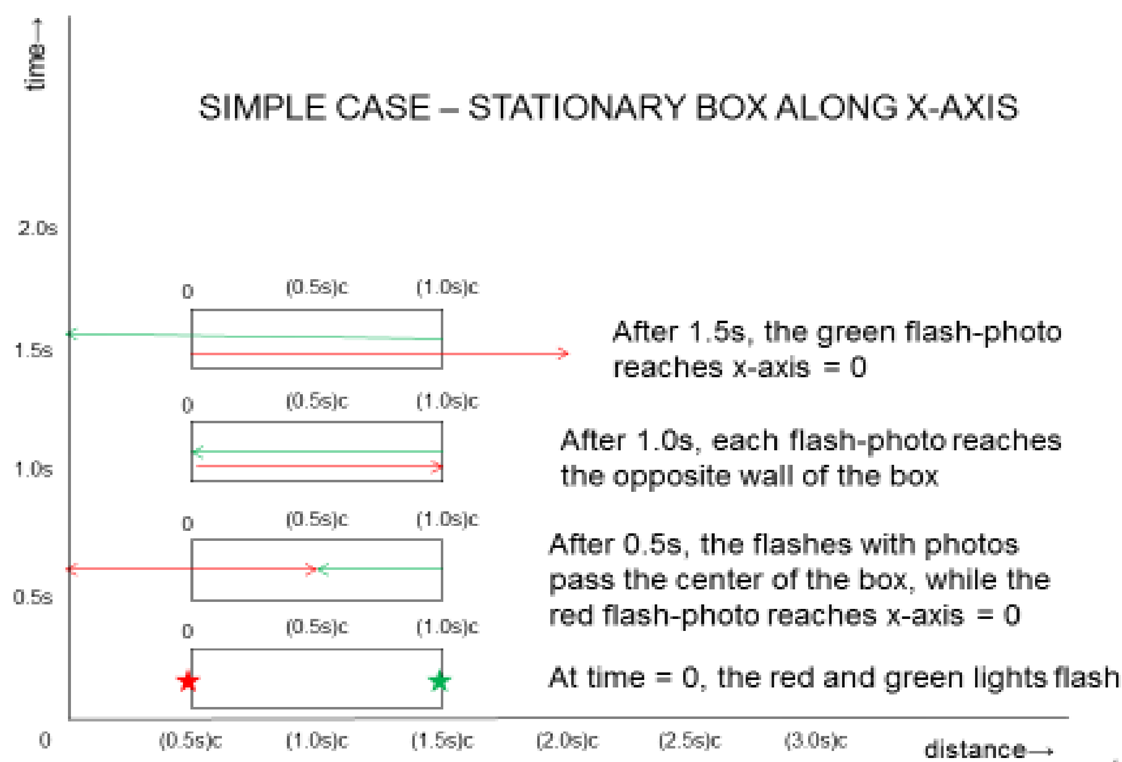
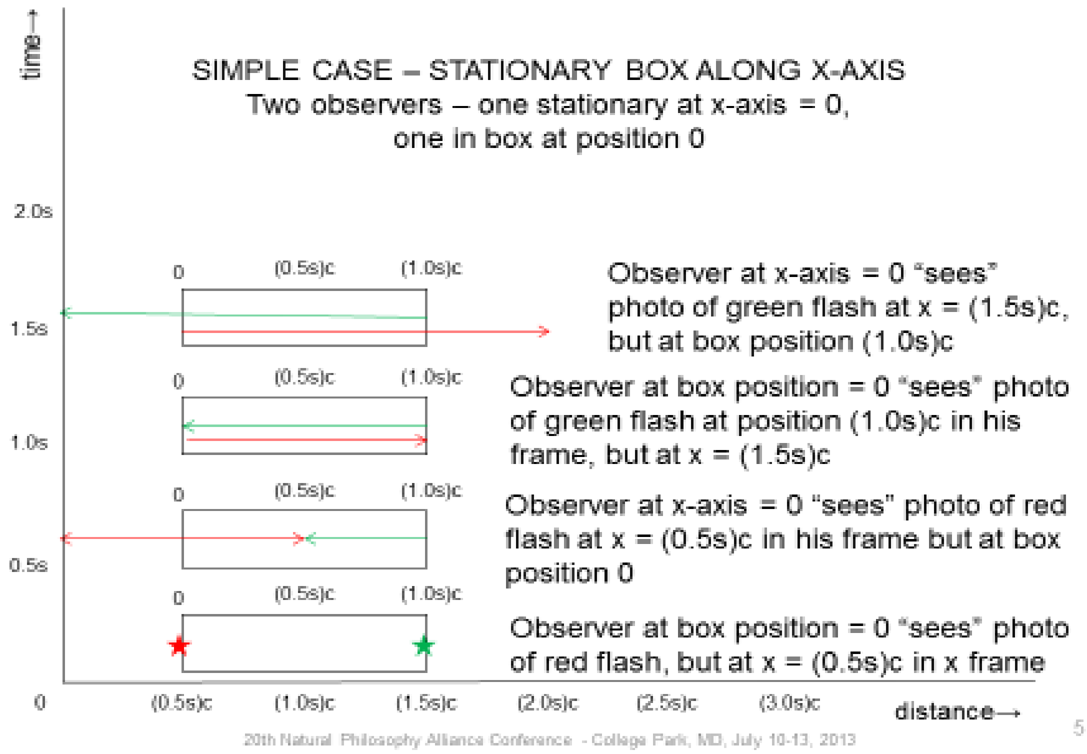
Initially, both frames have synchronized clocks that run at the same rate. These synchronized clocks are located all along the length of both frames, i.e., all along the box and the axis; and, within each frame, they record the same time everywhere, as they are synchronized. The box has a red light at one end and a green at the other, i.e., at positions = 0 and (1.0s)c in the box frame. Both flash simultaneously at time = 0 (same in both frames) when the box is aligned with positions (0.5s)c (red) and (1.5s)c (green) along the axial frame.



TIME DILATION IN RELATIVITY

In the first (simple) case, the box remains stationary. In the second, it moves horizontally at speed = 0.5c. By having the lights flash simultaneously at the ends of the box, the “photos” that reach the observers (at positions = 0 in each frame) record simultaneous positions for comparison to determine the “true” box length because both photos are taken at the same time, even though they do not reach the observers simultaneously. Each photo records the light flash and the corresponding positions and times in both frames when the flash occurred.





SIMPLE CASE – STATIONARY BOX ALONG X-AXIS
What does each observer "see?"

Time (s)	Stationary (x = 0)	Box (position = 0)
0	Nothing yet	Red flash-photo at 0 in box frame and x = (0.5s)c
0.5	Red flash-photo at x = (0.5s)c and box position 0	Nothing new
1.0	Nothing new	Green flash-photo at (1.0s)c in box frame and x = (1.5s)c
1.5	Green flash-photo at x = (1.5s)c and box position (1.0s)c	Nothing new
Each observer "sees" photos of light flashes that have traveled a distance of (1.0s)c in 1.0s in both frames [(1.5s)c – (0.5s)c = (1.0s)c along the x-axis and (1.0s)c – 0 = (1.0s)c along the box]. This is the trivial result, showing light traveling at speed (1.0s)c/(1.0s) = c		

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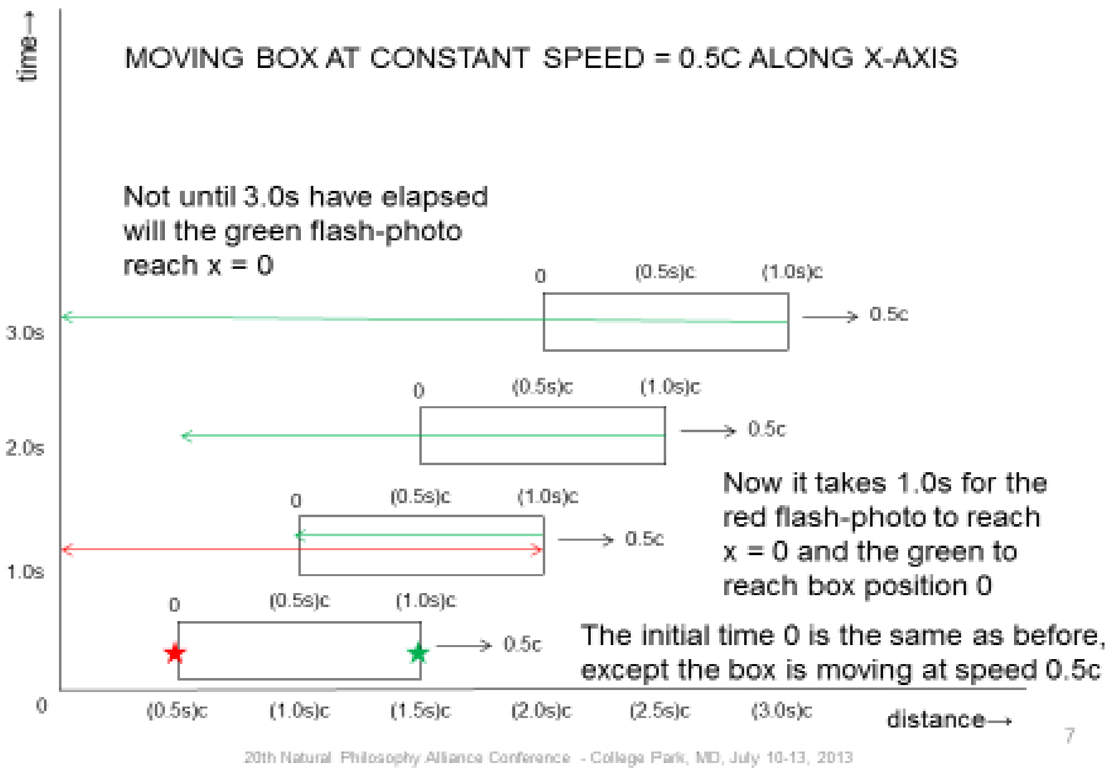
6



MOVING BOX AT CONSTANT SPEED = 0.5C ALONG X-AXIS
time→
Not until 3.0s have elapsed will the green flash-photo reach x = 0
Now it takes 1.0s for the red flash-photo to reach x = 0 and the green to reach box position 0
The initial time 0 is the same as before, except the box is moving at speed 0.5c
0
(0.5s)c
(1.0s)c
0.5c
3.0s
2.0s
1.0s
(1.5s)c
(2.0s)c
(2.5s)c
(3.0s)c
distance→
7
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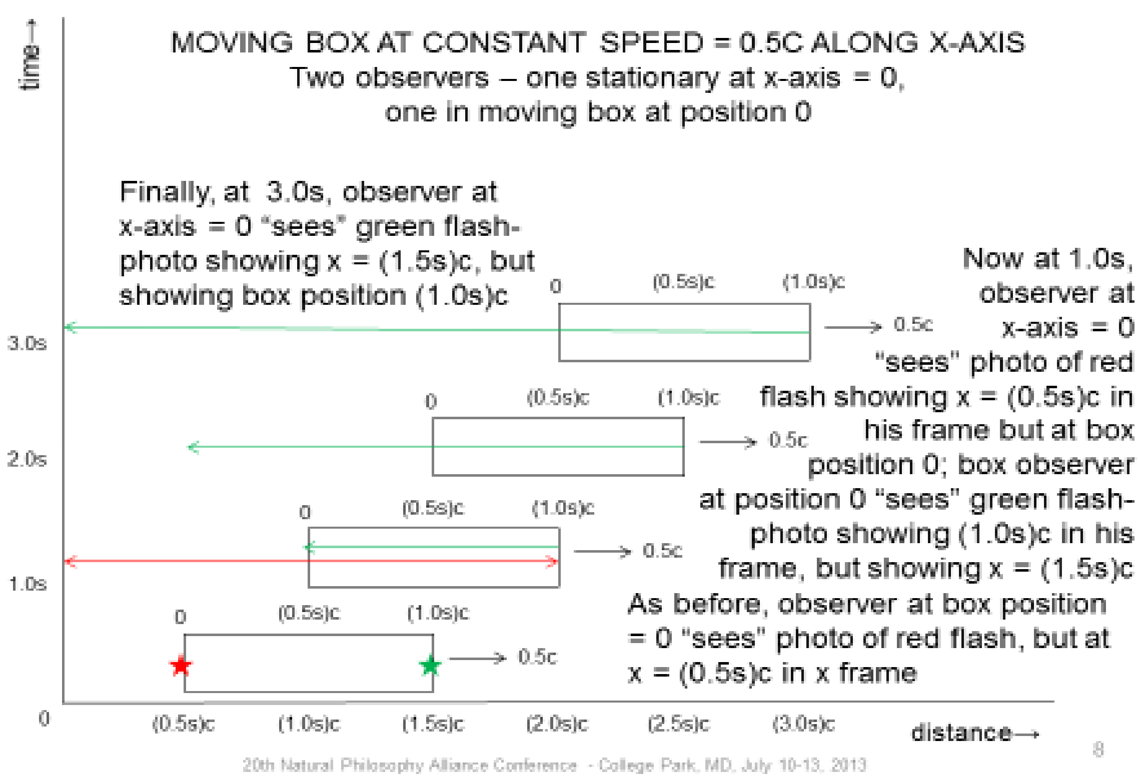

MOVING BOX AT CONSTANT SPEED = 0.5C ALONG X-AXIS
Two observers – one stationary at x-axis = 0, one in moving box at position 0
time→
Finally, at 3.0s, observer at x-axis = 0 "sees" green flash-photo showing x = (1.5s)c, but showing box position (1.0s)c
Now at 1.0s, observer at x-axis = 0 "sees" photo of red flash showing x = (0.5s)c in his frame but at box position 0; box observer at position 0 "sees" green flash-photo showing (1.0s)c in his frame, but showing x = (1.5s)c
As before, observer at box position = 0 "sees" photo of red flash, but at x = (0.5s)c in x frame
0
(0.5s)c
(1.0s)c
0.5c
3.0s
2.0s
1.0s
(1.5s)c
(2.0s)c
(2.5s)c
(3.0s)c
distance→
8
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MOVING BOX AT CONSTANT SPEED = 0.5C ALONG X-AXIS
What does each observer "see?"

Time (s)	Stationary (x = 0)	Box (position = 0)
0	Nothing yet	Red flash-photo at 0 in box frame and x = (0.5s)c
1.0	Red flash-photo showing x = (0.5s)c and box position 0	Green flash-photo showing box position 0 and showing x = (1.5s)c, while he is "at" x = (1.0s)c
2.0	Nothing new	Nothing new
3.0	Green flash-photo at x = (1.5s)c and box position (1.0s)c	Nothing new
Box observer at position 0 "measures" his elapsed time between flashes at 1.0s and box length (via photos) as (1.0s)c in both frames, but an elapsed time in x frame of only [(1.0s)c – (0.5s)c]/c = 0.5s		
Observer at x-axis = 0 "measures" his elapsed time between flashes at 2.0s and box length (via photos) as (1.0s)c in both frames, but an elapsed time in box frame of only [(1.0s)c – 0]/c = 1.0s		

SUMMARY - WHAT THE BOX OBSERVER "SAW"

Box observer at box position 0 "saw" red flash at time 0 while at x-axis position = (0.5s)c. One sec later, while at x-axis position (1.0s)c, he "saw" photo of green flash showing box position (1.0s)c. Relative to x-axis, he traveled a distance of only (1.0s)c – (0.5s)c = (0.5s)c while green flash traversed entire box length of (1.0s)c. Therefore, he judged that, while 1.0s elapsed on his clock, only (0.5s)c/c = 0.5s elapsed in x-axis frame, since speed of light is constant.

To box observer, his clock ran twice as fast as that in x-axis frame, a time dilation factor of 2.

SUMMARY - WHAT THE X-AXIS OBSERVER "SAW"

X-axis observer at x = 0 "saw" photo of red flash at time 1.0s showing x-axis position = (0.5s)c and box position 0. Two sec later, he "saw" photo of green flash showing box position (1.0s)c. Since speed of light is constant and photos indicated box length = (1.0s)c, the time elapsed in the box frame was (1.0s)c/c = 1.0s. However, in his frame, 2.0s elapsed.

To x-axis observer, his clock ran twice as fast as that in box frame, a time dilation factor of 2.

CONCLUSION

Per observer: "If my clock registers twice as much time to cover the same distance, my time must be running twice as fast as the time in the other frame."

Both observers see the same APPARENT time dilation, namely their (stationary) clock running twice as fast as the (moving) one in the other frame. However, in reality neither the box length nor the rate of time passage differs in either frame, even when there is relative motion.

Any "time dilation" is only APPARENT, not real.