

Re: Time dilation

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Androcles

I followed up a posting of yours to see if there is indeed a discrepancy to be found. I'm afraid there isn't:

Consider what happens to a moving clock that has been synchronised with an Earth clock as it leaves Earth, travels to a point a fixed distance, 1 light year (as measured by the earth bound observer) from earth and then returns. For simplicity, we'll make the journey occur at 0.866c in each direction. The moving clock transmits by radio its clock ticks which are received by the earth and counted. Note that a clock tick not only represents time, can be represented as a frequency it is also an event. With telemetry each tick could be uniquely identified. An event either takes place or it doesn't. No ticks can be lost or gained although we may be permitted to lose the odd one in the maths if we do not calculate to sufficient accuracy.

The Earth observer measures the time for the 2 way trip as $2/0.866 = 2.30947$ hrs and this works out at 8314 ticks at 1 tick/sec for his clock.

He sees the moving clock time dilated
 $t_1 = t_2 \sqrt{1 - 0.866^2/c^2} = t_2/2$ so will receive 4157 ticks.

The 'measuring rod' between earth and 'the fixed point' is stationary in earth's FoR and is 1 light-hour long. From the point of view of the observer travelling with the moving clock, he will see his clock as accurately ticking 1 tick per second but will see the 'measuring rod' length dilated such as to be 1/2 light-hour. His trip distance is therefore 1 light-hour total so he also sees his clock tick 4157 times.

Both observers therefore agree that the moving observer's clock has only ticked 4157 times compared to the earth bound observer's 8314 because the moving clock is going slower, the moving observer because the distance he travels is shorter.

What would the earth observer actually receive on his radio when listening for the ticks? They will be subject to Doppler shift. One can

apply the Doppler equation and get the same answer.

Outward journey

$$\begin{aligned}
 f' &= f(1-v/c)/\sqrt{1-vv/cc} \\
 &= f \cdot \sqrt{(1-v/c)/(1+v/c)} \\
 &= 1 \cdot \sqrt{(1-0.866)/(1+0.866)} = \sqrt{0.134/1.866} = 0.268 \text{ Hz},
 \end{aligned}$$

Earth will start receiving this frequency at $t=0$ it will stop when the tick which left the clock at the turnaround point reaches earth. The last tick (at this frequency) was transmitted at $t = 1/0.866 = 1.154735$ hrs it will take an hour to reach earth (1 light hour distance) so 0.268Hz will be received for $t = 2.154735$ hrs.

$$\text{Number of Ticks} = 2.154735 \times 60 \times 60 \times 0.268 = 2079 \text{ ticks}$$

Returning,

$$f' = 1 \cdot \sqrt{(1+0.866)/(1-0.866)} = \sqrt{1.866/0.134} = 3.731 \text{ Hz},$$

This frequency will be received for the remainder of the trip starting at $t = 2.154735$ and ending at 2.30946hrs a total of 0.154725hrs. The number of ticks = $0.1547344 \times 60 \times 60 \times 3.731 = 2078$ ticks.

The total number for both go and return is the same and the grand total = 4157 the same as previous figure (give or take a tick). Doppler shift will effect the interval between ticks but cannot effect the total number.

What if the Moving observer can receive, by radio, ticks from the earth bound clock. On the outward journey he will receive ticks at 0.268Hz and on the return at 3.731Hz.

Outward trip he starts receiving ticks at 0.269Hz at $t = 0$. At the turn around point he will have been receiving them for $0.5/0.866 = 0.5774$ hrs so will have received $0.5774 \times 60 \times 60 \times 0.269 = 559$ ticks.

On the return $0.5774 \times 60 \times 60 \times 3.731 = 7755$
a total of $(559 + 7755) = 8314$ which is the same as the earth bound observer counted.

Summery

Earth bound observer sees his clock tick 8314 times and the moving observers clock tick 2079 times at 0.268Hz on the outward journey and 2079 times at 3.731Hz for the return – a total of 4158 – half that of his own. He puts the difference down to time dilation.

The moving observer sees his clock tick 2079 on the outward journey which is for him half a light hour distance, and another 2079 on the return. The same as the earth clock received from him. On the outward journey he receives 559 ticks at 0.269Hz and on the return 7755 at 3.731Hz from the earth bound clock. Total received from earth = 8314 which agrees with that of the earth bound observer.

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to email convert the number from hex to decimal