

4.3: Faster Than Light?

choose your frame. then measure velocity!

Revelation number two strikes us as-still dreaming-we pass Lookout Station Number 8, 8 light-years from Earth: What speed! We glance out of our window and see the lookout station clock print out "Fourth of July 2010 A.D." - 10 years later than the Earth date of our departure. Our rocket clock reads 6 years. We are not shocked by the discrepancy in times for, apart from the change in scale from meters of light-travel time to years, the numbers are numbers we have seen before. Nor are we astonished at the identity of the spacetime interval as evaluated in the two very different frames. What amazes us is our speed. Have we actually covered a distance of 8 light-years from Earth in a time of 6 years? Can this mean we have traveled faster than light?

We have often been told that no one and no object can go faster than light. Yet here we are - in our dream - doing exactly that. Speed, yes, we suddenly say to ourselves, but speed in which frame? Ha! What inconsistency! We took the distance covered, 8 light-years, in the Earth-linked laboratory frame, but the time to cover it, 6 years, in the rocket frame!

Speed; Measure distance and time in same frame

At this point we recognize that we can talk about our speed in one reference frame or our speed in the other frame, but we get nonsense when we mix together numbers from two distinct reference frames.¹ So we reform. First we pick for reference frame the rocket. But then we get nothing very interesting, because we did not go anywhere with respect to the rocket - we just stayed inside.

$$\left(\begin{array}{c} \text{our speed} \\ \text{relative to} \\ \text{rocket frame} \end{array} \right) = \frac{\left(\begin{array}{c} \text{distance we cover} \\ \text{with respect to rocket} \end{array} \right)}{\left(\begin{array}{c} \text{time we take to cover} \\ \text{it in rocket frame} \end{array} \right)} = \frac{(0 \text{ light-years})}{(6 \text{ years})} = 0$$

In contrast, our speed relative to the Earth-linked reference frame, the extended laboratory, equals

$$\left(\begin{array}{c} \text{our speed} \\ \text{relative to} \\ \text{Earth frame} \end{array} \right) = \frac{\left(\begin{array}{c} \text{distance we cover} \\ \text{with respect to Earth} \end{array} \right)}{\left(\begin{array}{c} \text{time we take to cover} \\ \text{it in Earth frame} \end{array} \right)} = \frac{(8 \text{ light-years})}{(10 \text{ years})} = 0.8 \text{ light-speed}$$

In other words we - and the rocket - travel, relative to Earth, at 80 percent of the maximum possible speed, the speed of light. Revelation number two is our discovery that speed in the abstract makes no sense, that speed has meaning only when referred to a clearly stated frame of reference. Relative to such a frame we can approach arbitrarily close to light speed but never reach it.

1 Speed: Measure distance and time in same frame

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