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A Simple Argument against Tachyon Detectability

An interesting introductory relativity problem is one which might be termed "The Great Train Robbery." It is discussed in Ford's book[1] as an apparent paradox but one which can be resolved so long as no signal can travel faster than light. The purpose of this note is to argue that if tachyons existed and were detectable, then the paradox would be genuine and an inconsistency with special relativity would exist.

A train 1000 m long ($L' = 1000$ m) approaches a tunnel 500 m long ($D = 500$ m) at a speed v (relative to the tunnel) of approximately .8667 c, so that $(1 - v^2/c^2)^{1/2} = .5$. A band of train robbers decides to trap the train in the tunnel by setting off simultaneous avalanches at the two tunnel ends. They reason that the train should just fit, since to them the train's apparent length is

$$\begin{aligned} L &= (1 - v^2/c^2)^{1/2} L' \\ &= (.5)(1000)\ \text{m} \\ &= 500\ \text{m} \end{aligned} \qquad (1)$$

Suppose the train is traveling due west. Let E1 be the event consisting of the train engine just reaching the west end of the tunnel and the simultaneous avalanche at that end. Let E2 be the event consisting of the train end just completing its entry into the east end of the tunnel and the simultaneous avalanche there. The robbers carry out their scheme by determining ahead of time the instant at which the train will be completely inside the tunnel, and they pre-set their charges to explode at this instant. Thus, E1 and E2 are simultaneous in the robbers' frame.

On the other hand, according to the train guards, the tunnel is far too short for the train to fit into:

$$\begin{aligned} D' &= (1 - v^2/c^2)^{1/2} D \\ &= (.5)(500)\ \text{m} \\ &= 250\ \text{m}, \end{aligned} \qquad (2)$$

i.e., the tunnel appears to be only 250 m long, so the train can never be completely inside. The robbers' plan appears to be impossible.

The paradox is resolved by noting that the two events are not simultaneous in the train frame. Event E1 occurs when the train engine reaches the west end of the tunnel. At that train instant ¾ of the train is still outside the tunnel. There is a crash and the train crumples like an accordion at the west end of the tunnel. Meanwhile, back at the caboose, the train keeps moving along. The rear occupants are

[1]Kenneth W. Ford, Basic Physics (Blaisdell Publishing Co., Waltham, Mass., 1968), p. 669.

unaware of imminent disaster until the caboose just enters the tunnel, whereupon the second avalanche occurs (event E2). The time lag between the events, in the train frame, is

$$\begin{aligned} T' &= \text{excess train length/train speed} \\ &= 750 \text{ m}/.8667 \text{ c} \\ &= 2.88 \times 10^{-6} \text{ sec.} \end{aligned} \qquad (3)$$

Afterward, everyone agrees that a wrecked train is trapped inside the tunnel.

The question then becomes: could the caboose have been saved had an emergency brake of some sort been activated? This would have required a signal from the front of the train. Assuming the signal could travel no faster than light, then the time it would take to reach the caboose would be approximately (ignoring the caboose length)

$$\begin{aligned} t' &= L'/c \\ &= 1000 \text{ m}/3 \times 10^{8} \text{ m/sec} \\ &= 3.33 \times 10^{-6} \text{ sec,} \end{aligned} \qquad (4)$$

therefore, $t' > T'$, and the signal could not reach the caboose before E2 occurred.

Now consider what could happen if tachyons existed and were detectable. In that case an interaction of some sort between tachyons and normal matter or photons would exist. A tachyon technology might then be developed which could enable a tachyon emergency signal system to be installed on the train. When E1 occurred, a beam of tachyons could be broadcast by the engine and received at the caboose in time to activate an automatic braking system which could save the caboose.

This result would be a genuine paradox. One might argue that the time necessary for release of the tachyons would be too long for the system to work. To overcome this objection, we need only imagine scaling up the length of the train and the tunnel until the response time of the signal system is negligible compared with the time lag between the two events (as seen by the train observers).

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