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A Logical Contradiction from Tachyons*

by

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ABSTRACT

It is shown that the existence of particles that can travel faster than the speed of light (tachyons) would lead to the possibility of creating physical experiments in which any possible outcome would contradict the hypotheses.

A recent proposal[1] that particles (tachyons) that travel faster than the speed of light (c) could exist without contradicting known portions of physical theory has been followed by a proof[2] that through the use of tachyons, one could achieve situations where an effect could precede its cause. In detail, Newton[2] showed that although on a microscopic level, the energetics of emission and abosrption may be interchanged in frames where the particles move backward in time, one can still use statistical ideas to uniquely label the processes as cause and effect in an invariant manner. It will be shown here that this possibility leads to physical problems such that the laws of physics imply two contradictory answers.

The present paper is based on the possibility of constructing simple devices of the type described by Newton: boxes containing tachyons that can be released at will, and devices that detect tachyons through recoil. The release of tachyons from a box will be referred to as "emission^c", with the superscript to remind us that Newton's definition of emission in a causal sense may be made independently of the energetics, and the detection process will be referred to as "detection^c", to remind us that in some reference frames "detection^c" will involve loss of energy to the detector, not gain. It will be presumed that a tachyon detector[c] can be used to operate other devices, e.g., a tachyon emitter[c].

The physical situation leading to a contradiction requires two tachyon emitters[c] and two tachyon detectors[c]. One emitter[c] E_R is placed at the origin P of coordinate system R, and connected to a detector[c] D_R and a clock as follows: if any tachyons have been detected[c] at P before $t = 0$, D_R operates a switch turning off E_R so that it cannot operate (this will be called "condition red" for E_R), while the clock is connected so that if E_R is in "condition green" (that is, not in condition "red"), E_R will emit[c] an isotropic burst of tachyons of velocity $v > c$ at $t = 0$. The other emitter[c] and detector[c] of tachyons are placed so that they have zero velocity in a new coordinate system S (coordinates in R are x,t; in S they are x',t') which has velocity u in the x-direction with respect to S, where

$$u > \frac{2v}{1 + v^2/c^2} \; ; \qquad u < 1 \; . \tag{1}$$

Condition (1) is a little stronger than Feinberg's condition[1] $uv > c^2$, but is consistent with it. The reason for choosing (1) will become apparent.

The second detector[c] D_S is connected to the second emitter[c] E_S in a manner of a transponder: that is, E_S emits[c] tachyons at once upon receipt of tachyons by D_S, and under no other conditions.

The physical construction of E_S is to be identical with that of E_R so that it emits[c] tachyons having speed $\underline{v}$ in $\underline{S}$. The transponder assembly (D_S and E_S) is placed at $x = 1$ when $t = 0$. Thus, its trajectory is

$$x = 1 + ut \; ; \qquad y = z = 0 \; . \tag{2}$$

Henceforth, the y and z coordinates will be suppressed, as only tachyons with $v_y = v_z = 0$ will be considered.

Now suppose we set E_R at condition "green" at $t = -\infty$ and see what happens. At $t = 0$, E_R emits tachyons, which go in all directions with speed v. Some go right along the x-axis, and their trajectory is

$$x = vt \; . \tag{3}$$

These meet the transponder at an event M found from (2) and (3)

$$x_M = \frac{v}{v - u} \; ; \qquad t_M = \frac{1}{v - u} \; . \tag{4}$$

The various events are illustrated in a Minkowski diagram, Figure 1. Consider now the tachyons emitted[c] by the transponder from event M in the <u>negative</u> x' direction. These have $dx'/dt' = -v$. By the Einstein velocity transformation law, or directly from the Lorentz transformation, one finds that these secondary tachyons have the trajectory

$$x = x_M - (t - t_M)\,\frac{v - u}{1 - vu/c^2}\ . \tag{5}$$

We find the event Q at which these tachyons intercept the t-axis be setting $x = 0$ in (5):

$$x_Q = 0\ ; \qquad t_Q = \frac{1}{(v - u)} + \frac{(1 - vu/c^2)v}{(v - u)^2}\ . \tag{6}$$

Assumption (1), however, implies

$$t_Q < 0\ . \tag{7}$$

But now we have a contradiction: E_R must be in condition "red" at $t = 0$, and hence does not emit[c] tachyons. But then, they would not be detected at M, in which case E_R would be in condition "green" at $t = 0$ ... , etc. That is, either the assumption that E_R does or does not emit tachyons at $t = 0$ leads to the opposite assumption. Hence, either tachyons do not exist, they do not obey relativity theory, or some other fundamental assumption of physics must be modified, such as the laws of cause and effect.

ACKNOWLEDGMENT

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REFERENCES

1. Feinberg, G., Phys. Rev. 159, 1089 (1967).

2. Newton, Roger G., Phys. Rev. 162, 1274 (1967).

FIGURE CAPTION

Figure 1 Minkowski Diagram for the physical situation under consideration. The light diagonal lines are lines of $x' = \text{const}$. The fact that the tachyons from P to M move backward in time as seen in the S (x', t') frame is shown by their making a larger angle with the light cone than the x' axis. It should be no more surprising that the tachyons from M to Q move generally downwards in the plot; their sense of time-propagation is reversed in R (x, t) but not in S. E_R and D_R have the t-axis as their trajectory.

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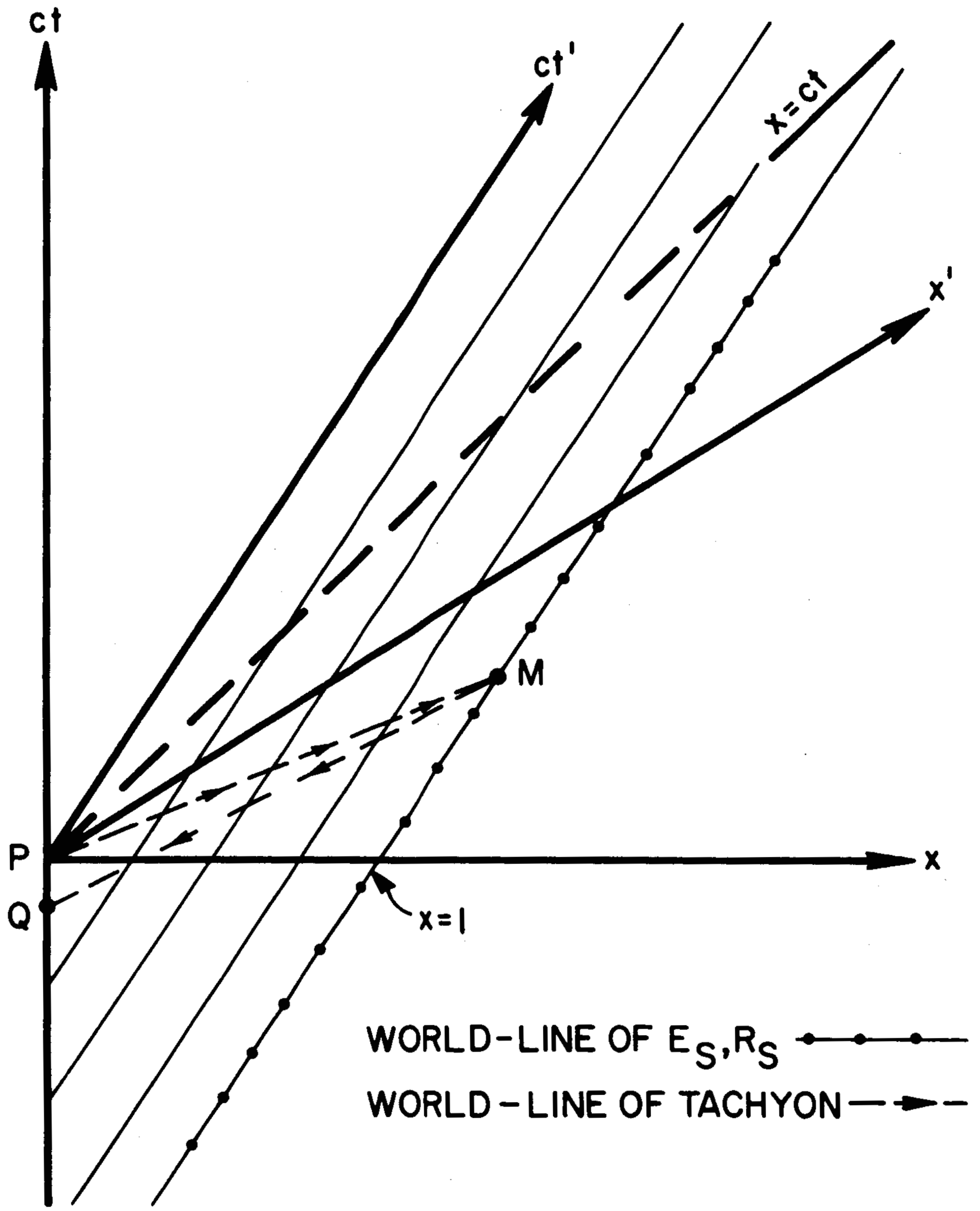

FIGURE 1