Tachyon – A Non-Existent Particle

A. Sfarti

ABSTRACT

In a 1967 paper [1], G. Feinberg conjectured about the possibility of “faster-than-light” particles. In the current note we prove his conjecture to be false by showing that he missed several key counter-arguments to their existence. We explain why the existence of tachyons contradicts both relativistic kinematics and relativistic dynamics. Our paper is divided in two sections: the kinematic counter-arguments and the dynamics counter-arguments.

Keywords: tachyon, relativistic speed composition, relativistic total energy, causality violation.

Published Online: March 15, 2021

ISSN: 2684-4451

DOI : 10.24018/ejphysics.2021.3.2.56

A. Sfarti*

Computer Science Department.
UC Berkeley, Berkeley, CA, USA.
(e-mail: egas@pacbell.net)

**Corresponding Author*

I. THE KINEMATIC ARGUMENT

In chapter II of his paper [1], Feinberg writes that the “value $v = \infty$ is allowed for tachyons” and that “

$$\frac{v'^2}{c^2} = 1 + \left(\frac{v^2}{c^2} - 1\right) \frac{1 - u^2/c^2}{(1 - uv/c^2)^2} \text{ so that } v' > c \text{ if } v > c \text{ “. As}$$

we will see, the condition $v' > c$ if $v > c$ is necessary but not sufficient. Indeed, assume that the tachyon is traveling at speed $v > kc, k > 1$ along the x-axis in frame F. Assume that frame F' is moving also along x-axis with speed u . According to the speed composition rule, the tachyon speed in frame F' is:

$$v' = c \frac{kc - u}{c - ku} \quad (1)$$

The above results into a function that:

a. Has a vertical asymptote at $u = \frac{c}{k}$ where the speed of the tachyon “jumps” from $+\infty$ to $-\infty$. In other words, as the speed u between frames F and F' increases uniformly from 0 to $\frac{c}{k}$ and beyond, the speed of the tachyon makes an excursion towards $+\infty$ only to drop instantaneously to $-\infty$. Something totally unphysical happens in frame F' as its relative speed with respect to frame F reaches $u = \frac{c^2}{v}$: the speed of the tachyon oscillates abruptly between $+\infty$ and $-\infty$, a physical impossibility.

In section II. 3 Feinberg does talk about the inversion of propagation direction through a Lorentz transform.

b. Yet, Feinberg fails to notice completely that the change of direction of propagation makes the speed “jump” along the

vertical asymptote from $+\infty$ to $-\infty$ resulting into infinite acceleration, jerk, etc., a totally unphysical situation. Besides, why would this strange situation be tied to the speed of the tachyon via the proportionality constant k ?

c. The tachyon reverses the sense of motion for $c > u > \frac{c}{k}$

with $-\infty < v' \leq -c$.

d. The situation is just as unphysical if F and F' exchange roles. In this case:

$$v' = c \frac{kc + u}{c + ku} \quad (2)$$

That means that $kc \geq v' \geq c$ when $0 \leq u < c$ with v' decreasing when u increases. As we can see, in all the above cases, the tachyons exhibit unphysical properties.

e. Feinberg tries to wave off the speed inversion that occurs at $u = \frac{c^2}{v}$ by invoking a time interval “reversal”. But time interval reversals have been known to violate causality. As an alternative, one can claim that causal loops are formed when frames of reference have relative speeds [8] $v > \frac{2u}{1 + \frac{u^2}{c^2}}$.

Much literature has been written on this subject, trying to justify the existence of tachyons on kinematic grounds [2]-[7] but, as we will see in the next paragraph, the final nail in the coffin is produced by a contradiction between their existence and the dynamics of special relativity.

II. THE DYNAMIC COUNTER-ARGUMENT

In the frame F' moving at speed v with respect to frame F, the total energy of the tachyon moving at speed $u > c$ is, according to the Lorentz transforms applied to energy-

momentum:

$$E' = \frac{\mu(c^2 - uv)}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (3)$$

The above means that as the speed v of frame F' with respect to frame F increases from 0 to $\frac{c^2}{u}$ and beyond, towards the upper limit, c , the total energy changes sign from positive to negative. But that contradicts the fact that, according to equation (3) in the Feinberg papers [1], [5], the total energy of the tachyon moving at speed $u' > c$ has to be positive at all times:

$$E' = \frac{\mu c^2}{\sqrt{\frac{u'^2}{c^2} - 1}} \quad (4)$$

We can see that not only the kinematics of the “tachyons” are self-contradictory but so are the dynamics as well, to an even greater and more decisive extent.

III. CONCLUSION

Either tachyons exist and special relativity is wrong and causality violations can exist and total energy can become negative or special relativity is right and there are no causality violations and tachyons do not exist. We are inclined to believe the latter. The tachyons have never been observed in the 53 years that passed since Feinberg published his paper. We have disproved Feinberg’s conjecture about the physical existence of tachyons.

REFERENCES

- [1] G. Feinberg, “Possibility of Faster-Than-Light Particles”, *Phys.Rev.*, 189, vol. 5, 1967.
- [2] A. Chodos, A.I. Hauser, V.A. Kostelecky, “The Neutrino as a Tachyon”, *Phys. Lett. B*, 150, vol. 431, 1985.
- [3] E. J. Copeland, M. R. Garousi, M. Sami, S. Tsujikawa. “What is needed of a tachyon if it is to be the dark energy?”, *Phys. Rev. D*, 043003, vol. 71, 2005.
- [4] J. A. Parmentola, D. D. H. Yee, “Peculiar Properties of Tachyon Signals”, *Phys. Rev. D*, 1912, vol. 4, 1971.
- [5] G. Feinberg, “Lorentz invariance of tachyon theories”, *Phys. Rev. D*, 1651, vol. 17, 1978.
- [6] Hill J.M., Cox B.J., “Einstein's special relativity beyond the speed of light”, *Proc. R. Soc. A* 468, 2012.
- [7] Hajnal A., Madarász J., Némethi I., Székely G., “A note on ‘Einstein's special relativity beyond the speed of light’ by James M. Hill and Barry J. Cox”, *Proc. R. Soc. A* 468, 2013.
- [8] Einstein, A. “On the relativity principle and the conclusions drawn from it”, *Jahrbuch der Radioaktivität und Elektronik*, 4, 1907.