

SPECIAL RELATIVITY AND FASTER-THAN-LIGHT PARTICLES: HOW TO APPEAL TO BANANA PEELS†

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MOTIVATING THE DISCUSSION

In 1949, Kurt Gödel [3] discovered solutions to the Einstein field equations showing that backwards time travel is not physically forbidden, and further outlined a hypothetical “rocket ship” on which “it is possible...to travel into any region of the past, present and future and back again” [4, p. 432]. Though his findings were initially challenged, later research dispelled these charges and confirmed Gödel’s original findings.¹ Such discoveries (and imaginative science fiction novels) fueled philosophical debate. The naïve argument against the possibility of time travel is a quick *reductio ad absurdum*: there cannot be time travel because it would imply contradictions, such as the ability to go back in time and prevent one’s own birth. However, such arguments are not conclusive.

It is also not physically forbidden, according to Einstein’s special theory of relativity, for particles to travel faster than light. The existence of such particles, called “tachyons” (from the Greek *tachys* meaning “fast”), has been a topic of debate over the last 40 years; as stated in *Special Relativity: Applications to Particle Physics and the Classical Theory of Fields* (1992), “Experimentalists have been making all possible efforts in the search for tachyons since the idea was first floated...in 1962” [7, 218]. These particles bear heavily on the question of whether quantum mechanics is incompatible with relativity. Quantum-mechanical experiments suggest that there is something like instantaneous causation at a distance, whereas a central tenant of relativity is that nothing can be accelerated beyond the speed of light. Thus, there is tension around the question of whether tachyons are the ‘bridge’ between quantum mechanics and relativity.

However, tachyons pose problems similar to those of time travel, since these particles seem to make possible paradoxes involving sending signals

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¹See [15], [13], and also [11] for the most recent discussion (2003).

into the past. In this paper, I address the question of whether tachyons can exist if the special theory of relativity is true, in light of debates in the philosophical literature on backwards time travel. I will argue that there are logically possible worlds in which special relativity is true and tachyons exist, and strangely, not only is it possible for our world to be one of these, but it is not straightforwardly improbable that our world is.

FASTER-THAN-LIGHT PARTICLES?

It is a common misconception that the theory of special relativity implies that nothing can travel faster than the speed of light. This assumption is deeply seeded. In earlier writings from Poincaré and Einstein, a central axiom of special relativity, that the speed of light is *invariant*, was understood slightly differently: “the speed of light [was] treated as the absolute *limit* of all speeds” [14, p. 130-131]. This is not true of special relativity.

To dispel this notion, consider the following thought experiment, which shows why at least *some* things can travel faster than the speed of light (c). “Imagine a powerful searchlight” (FIGURE 1) which is rotating very rapidly and which is located at the center of very large hollow sphere. It follows that, so long as the radius of the sphere is sufficiently large, “the searchlight beam will sweep along the inner side of the sphere with a velocity greater than c ” [9, p. 278]. The question this paper is concerned with is whether it is consistent with special relativity for single particles to travel faster than c .

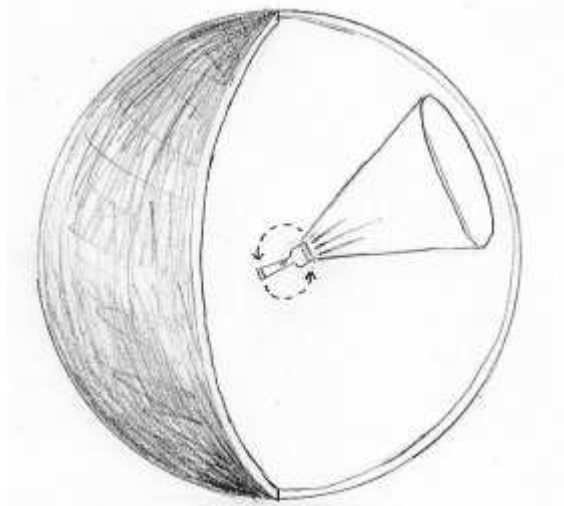


FIGURE 1

To see how tachyons are not *explicitly* inconsistent with special relativity, one can examine the equations for mass and energy, where v is velocity, m_0 is rest mass and c is the speed of light:

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad E = mc^2$$

It follows from these equations that a particle can never be *accelerated* up to c , as that would entail the mass and energy of the particle becoming infinite. Yet it does not follow that particles cannot travel equal to or even faster than c ; the equations do not “forbid a particle to have the speed of light at the time of its creation” [7, p. 217]. Whether faster-than-light particles would have an ‘intelligible’ mass has been a source of uneasiness, since the rest mass of such particles is represented by an imaginary number. However, the rest mass of tachyons should be of no concern: as slower-than-light particles cannot be accelerated to c , tachyons cannot *decelerate* to c (as this would also require infinite energy) and so their rest mass is somewhat irrelevant. Worries about the relativistic mass of a tachyon are circumvented by employing a method for deriving a real numbered *meta-mass* [7, p. 218]. Among the other strange properties of tachyons is that they have negative energy and travel faster as they lose energy. Yet again, these oddities are not necessarily causes for concern, for they happen to be consistent with special relativity.

In so far as tachyons are not straightforwardly incompatible with special relativity, it may be reasonable to assume that there is some probability they exist. One can catch particle physicists employing this line of reasoning: “We, therefore, conclude that particles moving faster than light can exist” [7, p. 218]. As Paul Fitzgerald points out, that “last mad inferential leap is...summed up in ‘Gell-Mann’s totalitarian principle’ that *whatever is not forbidden is compulsory*” [2, p. 415]. Before prematurely assuming any such probability that tachyons exist, it is necessary to consider what the existence of such particles would imply.

This more logical line of reasoning is essentially that of a *reductio ad absurdum* argument. One can assume the special theory of relativity as a premise, and then add the conjecture that tachyons exist into the set of premises. If a logical contradiction can be derived, it follows that these two sets of assumptions are inconsistent. As special relativity is itself mathematically consistent, if one assumes that special relativity is ‘true,’ and a contradiction is derived, then one can conclude that it is false that tachyons can exist given that relativity is true. In evaluating applications of this method, one must become familiar with how tachyons fit into the picture of special relativity, which is the purpose of the next section of this paper.

TACHYONS IN MINKOWSKI SPACE

A Minkowski spacetime graph (FIGURE 2) can be used to illustrate how tachyons, although seemingly consistent with special relativity, begin to look problematic. The ‘Minkowski world’ consists of a vertical axis (t) representing time in an inertial reference frame, and a horizontal axis (x) representing what is called a *plane of simultaneity* for a reference frame (or the state of the world at a time). With this structure, any given point in Minkowski spacetime can be represented as coordinates (x, t) . The ‘history’ of an object can be represented by a *worldline* showing which Minkowski coordinates an object has occupied over time.

From all reference frames, a light cone extends forwards and backwards from the origin. The light cone is depicted graphically by two lines ℓ_1 and ℓ_2 such that ℓ_1 is $t = x$ and ℓ_2 is $t = -x$, i.e. they intersect at the origin of a reference frame such that the four right angles of the x and t axes are all bisected. The cone spanning upwards along the t -axis demarcates the locations to which light travels from the center (origin) of the inertial reference frame, and the cone extending down from the origin represents where light at the origin could be arriving from. By referring to the light cone, one can distinguish *timelike separated* and *spacelike separated* spacetime locations (or events) from the origin. An event is timelike separated from the origin if the event is ‘reachable’ from the origin at speeds equal to or slower than the speed of light. Two events are spacelike separated, or “elsewhere,” if light could not travel from one spacetime location to the other [8, p. 54]. It follows that coordinates which are timelike separated from the origin are ‘inside’ the light cone, whereas coordinates which are spacelike separated from the origin are ‘outside’ the light cone.

All objects and particles *except tachyons* have worldlines consisting only of timelike separated coordinates. Conversely, since tachyons travel faster than light, the worldlines of tachyons consist only of spacelike separated events. This distinction is central in understanding how tachyons may be inconsistent with relativity. The significance comes from the fact that the *temporal order* of timelike events is Lorentz invariant, meaning that the order of events as observed from any reference frame is fixed. What this implies is that “it is meaningful to talk of ‘earlier’ or ‘later’...independent of the inertial frame of reference” [10, p. 87]. But only for *timelike* separated events do ‘causes’ necessarily precede ‘effects’ from the perspective of *any* inertial reference frame. This commonsense relationship does not hold for spacelike separated events.

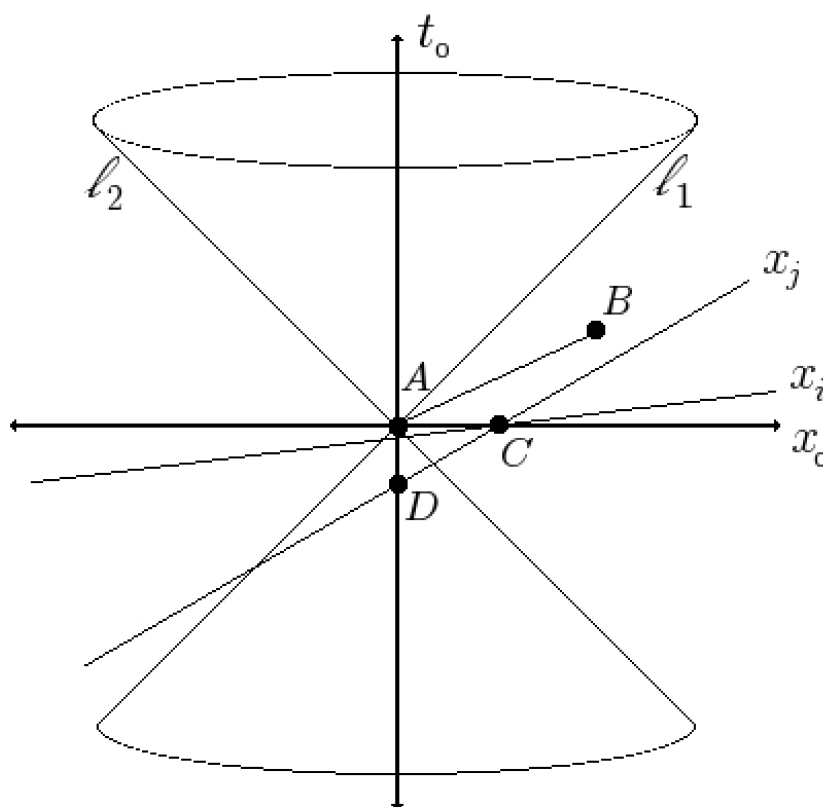


FIGURE 2

See FIGURE 2 where spacelike events A and B are ‘connected’ by the transmission of a tachyon. Imagine that a tachyon is sent from event A to event B . From the standpoint of an observer i in the inertial reference frame for which the x_i -axis is the plane of simultaneity, event A occurs before event B . The reader can verify this by placing a pencil on FIGURE 1 so that it lines up along line x_i , and then sliding the pencil up the graph while keeping the slope of the pencil constant.² The pencil will ‘encounter’ event A before event B . However, from the inertial reference frame for which the x_j -axis is the plane of simultaneity, an observer j would actually see event B before event A . One can verify this again by imagining the x_j plane ‘sliding up’ the t -axis and contacting B before A . Hence, the observers see the events taking place in opposite orders. Strictly from the standpoint of special relativity, one has no grounds on which to insist that one reference frame is seeing the ‘correct’ order of events, although in this example it was posited that the tachyon traveled from A to B .

²For simplicity, the t axis is being used instead of what should actually be a separate t_i axis.

Since the causal order of *spacelike* events is *not* Lorentz invariant, tachyons threaten our common understanding of causes as preceding effects. However, the problem gets worse. Instead of just some observers seeing the ‘wrong’ causal order, it is easy to envision a case for which “the cause is later than the effect for *all* coordinate-systems” [2, 420]. Examining FIGURE 1 again, interpret event A as a tachyon emitter firing off a tachyon. This tachyon travels at some arbitrarily fast speed and is redirected by a tachyon deflector at C and is absorbed at event D along C ’s plane of simultaneity x_i . Since D is inside the past light cone of A , it can be said that D is in the *absolute* past of A , since the order of *timelike* events A and D is Lorentz invariant. That tachyons can travel into the absolute ‘local’ past is the first major cause for alarm concerning the possible existence of tachyons.

THE REINTERPRETATION PRINCIPLE

That tachyons threaten the preservation of causal order is admittedly bizarre. However, this seems an insufficient reason by itself to conclude that tachyons are impossible entities: there is no logical contradiction. Nevertheless, it is no surprise that the proponents of tachyons set to work developing a method of dealing with this oddity. A clever trick called the *reinterpretation principle* was developed. Devised by Bilanuik and Sudarshan in 1969, this method is touted as the most effective at separating tachyons from the problem of retrocausality which accompanies them [7, 220]. Consider a series of events similar to $\{A \rightarrow C \rightarrow D \rightarrow A\}$ as depicted in FIGURE 2. When such a series of events ensue, a tachyon is emitted at some time $t = 2$ and is absorbed at another spacelike event at time $t = 1$ (the tachyon travels backwards in time from all reference frames). One seems forced to conclude that causes no longer precede effects.

The reinterpretation principle turns this problematic aspect of tachyons to its advantage. Recall that tachyons have negative energy, a conceptual problem which the reinterpretation principle also fixes. Recall further that the speed of tachyons increase as they lose energy. It follows from the fact that “the energy of a particle is proportional to the time component of its four-vector...that the tachyon [traveling backwards in time] *has negative energy*” [6, 76]. In English: the equations describing a tachyon’s energy show that its quantity of energy is positively related to the direction it is heading in time. The reinterpretation principle bids us to reinterpret ‘receiving events’ of negative energy tachyons traveling backwards in spacetime as ‘emitting

events' of positive energy tachyons traveling *forwards* in time in the opposite spatial direction [14, p. 138-9]. In other words, from the framework of the absorbing event, instead of interpreting the event as the absorption of *negative* energy from a tachyon traveling *backwards* in time ('losing' energy), an observer can consistently reinterpret this event as the emission of a tachyon of *positive* energy *forwards* in time (still 'losing' energy).

Although the consistency of this move can be shown mathematically, it may seem a hard bullet to bite. A rough analogy may help. Imagine looking down at a billiards table, where the entire left half of the table is covered with billiard balls. One can reinterpret the moving of a section of balls to the right as the moving of the opposite of balls (the moving of non-balls) to the left. To be moving the things with ball-ness to the right is also to move the things with non-ball-ness to the left. In much the same way, the ability to restate the receiving of negative energy tachyons as the emitting of positive energy tachyons is legitimate.

Although it seems that such reinterpretation frees one of problems with retrocausality, this solution fails to generalize. The next section of this paper shows how the reinterpretation principle cannot be held to task on this point.

A PARADOX BEYOND REINTERPRETATION

Tim Maudlin provides an example of how causal direction can be correctly inferred from local event information [6, p. 100]. His account can be adapted into the following causal paradox, for which the reinterpretation principle offers no solution (see FIGURE 3). A French author finishes her manuscript at time t_0 and needs to provide a German translation for her publisher. However, she is not fluent in German and needs to send her manuscript to a German translator. Let event F denote her hooking-up her computer to a tachyon emitter, which fires-off her manuscript in Morse code to the German translator's tachyon-recording device, denoted by event R_1 . Note that one cannot reasonably reinterpret the order of these two spacelike events. To do so would be to admit of tachyons unexplainably shooting out of a recording device and miraculously into the barrel of a tachyon emitter in perfect French Morse code. Thus, the correct order of causality for events F and R_1 can be

A biconditional contradiction is derivable from this story. If the author needs her manuscript to be translated at time t_0 , then she has not received the translation yet. But if she sends it at t_0 , she receives the translation before she needed it. Conversely, if she already has a German translation at time t_0 , then she completed and sent her manuscript to be translated at time t_0 . Therefore, she needs a translation of her manuscript at time t_0 *if and only if* she does not need a translation of her manuscript at time t_0 . The reinterpretation principle can be of no avail in ridding this causal paradox.

A simplified version of the above paradox is Paul Fitzgerald's 'Logically Pernicious Self-Inhibitor,' a hypothetical paradox machine which consists of a tachyon emitter and a tachyon detection strip. The self-inhibitor emits a tachyon at some time t_1 *if and only if* it has not absorbed a tachyon in the last 5 minutes on its 'tachyon detecting strip.' If the reader will re-examine FIGURE 3, this machine is set up at the origin F such that it fires a tachyon at a deflector (at R_1) which deflects the tachyon to the machine's strip at R_2 . One can now ask: does this machine emit a tachyon at time t_1 ? Well, if it did, it would have detected a tachyon less in the last 5 minutes, so it would not emit a tachyon; the moral of Fitzgerald's story is that one could in principle rig up this kind of self-inhibiting machine that emits a tachyon at time t_1 *iff* it does *not* emit a tachyon at time t_1 . This last proposition is a contradiction, false in all possible worlds.

Paradoxes such as these are a matter of grave concern for the proponents of tachyons. But what exactly can one legitimately conclude from this paradox? Is it a proper *reductio ad absurdum* proof that tachyons cannot exist? There are arguments suggesting that it is not. It can be objected that such 'self-inhibitor' machines, though in principle constructible, could not actually be constructed. This objection misses the mark. That such a machine is in theory possible *is* the problem itself. One might also object that Fitzgerald's self-inhibitor paradox is committed to the assumption that tachyons can be *controlled* and *emitted* in a mechanistic fashion, and so only shows that *these* kinds of tachyons may be inconsistent with special relativity. However, there is no clear reason why a tachyon could not simply be released from a holding-chamber in which it has been flying around since the time of its creation. Further, so long as the direction and speed of an emitted tachyon is known in the roughest of estimations, self-inhibitor machines running for an arbitrarily long time would certainly seem to usher in the possibility of a paradox ensuing. As Tim Maudlin says, any ability to emit and observe

tachyons with some degree of “nomic correlation” would be sufficient for rigging up tachyon signaling paradoxes [6, p.81-2].

However, arguing that tachyons are consistent with special relativity does not commit one to posit that tachyons are broadly uncontrollable or unobservable. To show how one can bypass all these particular worries, I will now begin to set out such an argument. I will argue that, even if tachyons could in principle be used to send signals into the past, this is insufficient evidence for the conclusion that tachyons are inconsistent with special relativity.

BANANA PEELS AND ALL THAT

A defender of tachyons might grant both the controllability of tachyons as well as the constructibility of self-inhibitors, but still argue that tachyons are not outright logically inconsistent with relativity. This line of thinking goes back to David Lewis, though he was not talking about tachyons. He introduced the idea that only mundane occurrences are needed for preventing time travel paradoxes. As Lewis suggested about the auto-infanticide paradox, all that is needed to prevent someone from going back in time and killing themselves is for it always to be the case that “...some noise distracts him [or that] his nerves fail” [12, *as quoted by Smith*, p.366]. In trying to keep the auto-infanticide paradox alive, Horwich pointed out that one must still consider the case of some persistent individual who *constantly* goes back in time trying to kill their younger self. The result seems to be that time travel is not impossible but rather wildly *improbable*: “regular thwarting of [such attempts would] involve an endless string of improbable coincidences” [5, p. 123].

It is important to notice that Horwich’s ‘persistent auto-infanticide maniac’ amounts to the same idea as the self-inhibiting machine: both are arranged (or deranged, as it were) for reaching back into the past for the purpose of preventing there being any such future reaching into the past. Here is the Lewis-Horwich line as applied to the self-inhibitor machine: the tachyon emitter could simply jam at each attempt, or the wiring goes bad, or the operator slips on a banana peel before she can turn the power on, and so on. Such strings of coincidences are not impossibilities. It seems natural to conclude then that tachyons *could* exist in paradox-free harmony with relativity, and so there is no valid proof of a contradiction after all. A similar conclusion about time travel generally has been offered by J. J. Smith in his article in the *British Journal for the Philosophy of Science* (1997):

upon reviewing the Lewisian coincidence argument, he says that “Nothing more than...ordinary occurrences is required to stop the time traveler from killing his younger self...Hence, backward time travel it is *not* impossible” [12, p. 367]. Paul Fitzgerald makes a similar inference: “The first self-inhibitor fails to function because a screw comes loose; the second because an earthquake destroys it,... [This] sort of appeal to fortuitous accidents [does] show that tachyons are not intrinsically self-contradictory” [2, p.427].

However, the inference from ‘time travel requires the availability of improbable strings of coincidences’ to the conclusion ‘time travel is therefore improbable,’ is a bit of a jump. I think this simple ‘argument from coincidence,’ as it stands, requires supplementation. For consider the following possible counter-objection. Having assumed special relativity (which is mathematically consistent) is true, either tachyons existing is consistent with this assumption or a contradiction is derivable. The Lewisian holds that contradictions like ‘a tachyon is fired at t_2 *iff* it is not’ (or simply ‘ $P \leftrightarrow \sim P$ ’) do not *have* to obtain if tachyons exist, since any string of coincidences could always prevent such paradoxes. This is true, but arguing that a string of coincidences could *prevent* a tachyon-related contradiction evidently admits that such a contradiction could otherwise obtain in theory, or else there would be no need to appeal to strings of improbable coincidences. This seems to show that the Lewis-Horwich line is still committed to the following contradiction being derivable from the conjunction ‘tachyons exist and special relativity is true’: $\diamond(P \leftrightarrow \sim P)$. Of course, such a possibility, be it physical, metaphysical or logical, is a strange thing to admit of, since it is commonly held that contradictions *are impossibilities*, logically or otherwise. The result is that the Lewis-Horwich line seems to admit that *this* contradiction, ‘ $\diamond(P \leftrightarrow \sim P)$,’ is derivable from there being tachyons in the world of special relativity. Viewed from this angle, the Lewisian strategy seems an ineffective way of avoiding the *reductio* contradiction.

I will now flesh out what I take to be the fuller story of the Lewisian argument from coincidence, and show how it avoids the counter-objection that appealing to coincidences still admits of some otherwise possible contradiction. What is going on underneath the surface of the Lewisian argument is this. Let there be a possible world Ω_T , in which special relativity is true and where there are observable, controllable and transmittable tachyons. Does it follow that contradictions are possible in Ω_T ? So long as Ω_T is a logically possible world, the answer is trivially no. No matter how hard Horwich’s self-inhibitor maniac tries to reach back into the past to prevent his

now attempting to reach back into the past, his failure at this is guaranteed. It is guaranteed simply in virtue of the fact that he *is now* attempting to reach into the past (and thus he must have already failed), and moreover that his succeeding is impossible since it entails a contradiction. This is not to say that it was ever possible for his paradoxical intentions to materialize, no more than it is possible for me in this world to both assert P and not assert P in the same time and in the same respect, hard as I may try. If it is not literally derivable from this world's physical laws that I am forbidden to do this, this does not entail the possibility of $P \ \& \ \sim P$, nor does it imply that this world is not a logically possible one.

The relevant question is: could our world be the Ω_T world? In the Ω_T world, it is necessary that there be as many slippery banana peels readily available as there are attempts by self-inhibitor maniacs. So, in Ω_T , there would have to be something like what Fitzgerald calls a '*law of coincidence*' - a perfect regularity of impending paradoxes being interrupted somehow, *via* banana peels and so on. Fitzgerald claims that such a force of nature which without fail interrupts paradox by way of quotidian accidents is (1) oxymoronic and (2) is a 'law' that would fail at providing any "direct empirical support," and would also have no "indirect support from, or organic interplay with, accepted laws and theories"[2, p. 423]. Fitzgerald, who is arguing against the plausibility of tachyons, is saying that such a law is *ad hoc* an appeal as one can possibly make.

I think there is something to this and that the following thought experiment, introduced by J. J. Smith, bears on its proper interpretation [12]. Imagine all the objects around us are clearly marked with expiration dates, which represent the dates of their destructions. Perhaps God has labeled them as such, or what have you. I can see that my desk is marked to expire on August 20, 2014. Now, if it occurs to me that I should try and saw my desk in half today, I ought not be surprised to find that something prevents my doing this. Perhaps I cannot find the saw, or I slip on a banana peel and hurt myself while looking for it. Indeed, the desk is marked August 20, 2014 *because* I cannot find the saw and so on, and so it is not as if these coincidences are magically intervening. This thought experiment provides an analog to the time travel case: Horwich's auto-infanticide maniac can clearly see that his 'expiration date' must not be a date in the past, since otherwise he would not be plotting his own demise.

In what way then is it *improbable* that the maniac will repeatedly fail, or that the tachyon self-inhibitor repeatedly fails? I think the resolution of this

question comes down to the following. In our world, we can destroy desks at will, if we so wish. If all the world's philosophers decided today to conspire against their desks, and *all* their efforts were bested by banana peels and the like, that would be improbable because there would be no general empirical reason for the phenomenon, and no coherent causal story which could make sense of the occurrence in light of other interacting physical systems and laws. Yet if all the philosophers in the Ω_T world rigged up self-inhibiting tachyon machines (out of curiosity maybe), a series of coincidences similar to that of the thwarted desk massacre would be bound to happen. The problem is that this would be *expected* in Ω_T - with as lawlike a regularity as an unsupported pen falling to the ground. There would be something like a law of coincidence in the tachyon world Ω_T . But in our world, if philosophers' desks were not due to expire, the thwarted desk massacre would be unexplainable - it would truly be coincidental, since in our world the Ω_T 'law' would fail to have a general empirical explanation. In Ω_T , there must be as many coincidences at disposal as there are attempts by self-inhibitors; but in our world, tachyons existing is as likely as the strings of broadly unexplainable coincidences eventually needed at some point in history to avert contradiction.

There are certainly logically possible worlds in which special relativity is true and tachyons exist; the two notions are not deductively contradictory. Since contradictions are impossibilities, the physical laws of a possible world such as Ω_T need not forbid tachyon paradoxes, for such contradictions cannot actualize as a matter of logic. If by chance a world like Ω_T was on course for tachyon-related contradiction, it would be prevented some way or another with certainty. But this lawlike regularity would be quite different from laws like $F = ma$. There would be no general empirical reason for the regularity and it would not cohere with nor be explainable in terms of other laws, save the laws of logic; the laws of logic end up doing the work physical laws usually perform. If special relativity is true, tachyons existing in our world would be as probable as any endless slips on banana peels accompanying their existence. In the anticipatory absence of an explanation of how such occurrences would not be coincidental but rather regularities playing a role in a greater overall physical theory, tachyons existing seems as improbable as unexplainable mass failures by philosophers to destroy their office furniture.

However, it seems wrong to submit the quick conclusion that, therefore, it is improbable that tachyons exist. This is for the simple reason that, if tachyons did exist, the most expectable 'strings of coincidences' would be no

such thing at all: it would probably just be that no one ends up discovering how to make logically pernicious self-inhibitors. This also seems the right conclusion to draw about time travel generally: just because there *could* be a Horwichian auto-infanticide maniac, who attempts multiple time travel suicides, one would expect one preemptive accident to do the job - maybe he gets into a car accident, or is shot before his multiple attempts, or just never figures out how to travel backwards in time. There seem to be too many plausible ways in which time travel or tachyons can exist in the universe of special relativity for one to assert with any warrant that these possible phenomena are improbable (subjectively so, or whatever).

CONCLUSIONS

There is one indisputable truth concerning the literature on tachyons: the fact that the proponents of tachyons are always willing to resort to curious methods which allow them to maintain hope of the existence of their beloved hypothetical particles. Fitzgerald shares a similar sentiment: “I so admire the ingenuity which the tachyonites have shown in elaborating the physics of superluminality that I want them to emerge triumphant over the dragons of paradox” [2, 429]. Consider a semi-recent article by Frank Arntzenius, whereupon the fourth page he declares: “In fact, I claim that paradox-free globally deterministic Lorentz invariant tachyon theories exist.” He then outlines a theory of tachyons in which “one could think of ordinary particles as ‘bleeping’ every second of proper time and tachyons being exchanged between spacelike separated bleeps, without the ordinary particles changing their course” [1, p. 204]. Surely Arntzenius’ theory of ‘tachyons’ would never be able to be proved inconsistent with special relativity; as instruments of science and other objects of *our* world are made up of ‘ordinary’ particles, it would be impossible to observe these tachyons is they only fly around while our world ‘bleeps.’ Such trivially consistent accounts of tachyons leaves one wondering two things: (1) would it matter whether *this* sort of ‘tachyon’ could exist and (2) how could this type of theory possibly be falsified? Arntzenius seems delighted by this ability to rekindle the tachyonite’s hope: “I can also give you a recipe for producing somewhat more interesting tachyon theories at home” [1, p. 204]. Perhaps the “ingenuity” to which Fitzgerald was referring is in short supply.

The conclusion of this paper is that if “tachyon” is defined minimally, without additional *ad hoc* conditions such as unobservability or uncontrollability, then, given self-inhibitor type arguments, a world with tachyons *could*

be a very strange world indeed. Yet, there is no quick *reductio ad absurdum* suggesting tachyons cannot exist, and it is equally unfair to infer that, since tachyons *could* lead to wildly improbable and unexplainable regularities, it is therefore improbable that they exist.

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