

# A Different Resolution of the Twin Paradox

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It is suggested that the persistence of the twin paradox within special relativity theory (SRT) results from a deficiency of physics in that theory, due to its granting priority to kinematics. The missing physics concerns all aspects of the problem bearing on how the *relative motion* of the twins is apportioned between them – that is to say, how it is caused. The foundational idea behind special relativistic kinematics, expressed in the symmetry of the Lorentz transformation (LT), is that only (symmetrical) relative motion matters. That is a bad idea, in that it misdirects attention away from the causal aspect of the physics (in the same way as does General Relativity Theory’s exclusive focus on “geometry”). The mathematical symmetry of the LT and its inverse is spurious in the same sense that it would be spurious to assert a running rate symmetry of laboratory clocks and muon co-moving clocks in the 1977 CERN muon experiment<sup>[1]</sup>. All time dilation experiments exhibit clock running rate *asymmetry*. SRT, which treats symmetrical relative velocity as the sole relevant parameter, is thus locked into wrong answers. It lacks both means and motivation to grasp the asymmetry of the physics. Supplying that missing information resolves the twin problem through explicit recognition of action asymmetry.

# 1. Introduction

Since its proposal in 1911 by Paul Langevin, the twin paradox has proven to be one of the most enduring aspects of Einstein's special relativity theory (SRT). A statement of the problem has been provided by Wikipedia, as follows:

*In physics, the twin paradox is a thought experiment in special relativity, in which a twin makes a journey into space in a high-speed rocket and returns home to find he has aged less than his identical twin who stayed on Earth. This result appears puzzling because each twin sees the other twin as traveling, and so, according to a naive application of time dilation, each should paradoxically find the other to have aged more slowly. In fact, the result is not a paradox in the true sense, since it can be resolved within the standard framework of special relativity. The effect has been verified experimentally using measurements of cesium beam atomic clocks flown in airplanes and satellites.*

The same source goes on to identify several candidate “resolutions,” each involving some physical cause of *asymmetry*, as needed to invalidate the “naïve application of time dilation.” But the latter naïveté is fostered by the Lorentz transformation (LT) and its inverse, which imply symmetry of aging rates (symmetrical slow-running of clocks), a phenomenon never observed, and apparently contrary to experiment<sup>[1]</sup>. A typical one of these supposed resolutions<sup>[2]</sup> identifies *acceleration* as the agency of asymmetry, although the hallmark of SRT is its distinctive dependence on the unqualified motional symmetry implied by the *relativity of motion*; therefore seemingly not restricted to relative velocity but applicable to

all forms of relative motion, including the higher time derivatives of separation distance. In that case acceleration *per se* does not spoil the *motional* symmetry of the twins, and the “paradox” (actually a disagreement with experimental fact) persists. Note that the mere existence of any *physical* symmetry-breaker implies the descriptive invalidity of the mathematically symmetrical LT. On this point the LT is completely inflexible. Asymmetry of steady clock running rates, a demonstrated attribute of physical clocks, is incorrectly *described* by symmetrical mathematics of any kind. If the LT is invalid, then SRT is invalid, since it offers nothing better. The Wikipedia assertion about the twin paradox that “it can be resolved within the standard framework” is consequently, to put it bluntly, no more than a tactic designed to protect the sacrosanct LT by stigmatizing any challenging of it as “naïve.” Because each generation produces a few misfits who resent bull-dozing tactics of this sort, it is easy to understand the indefinite longevity of what is euphemistically called a paradox. The trouble strikes all the way back to the basic premise on which SRT is founded, that the physics can be fully and consistently described by reference to *relative motion* alone. In what follows I shall seek to refute that premise. We shall find that it is profoundly unwise to put the cart before the horse, kinematics before physics.

First, a preparatory word about *proper time*. It has a property of numerical invariance, but this does not mean that the flow rate of physical time (or the rate of a naturally-running clock) is invariant. In every inertial system the half-life of the muon is 2.2 microseconds. That *number* is invariant. But, if the muon is at rest in a “moving” system  $S'$  characterized by  $\gamma$ , then in  $S'$  its (proper time) half-life is 2.2 microseconds; yet in the non-moving system  $S$  that same muon's half-life is measured as  $2.2\gamma$  microseconds. In short, clocks run objectively  $\gamma$  times slower in  $S'$ , so the meaning of the “second”

changes; while a half-life quantifies the number of these changed “seconds.” Invariance of a number is thus apt to be misleading, since the physical meaning of that number (in terms of clock-measured elapsed time) is *not* invariant.

Very well ... let us approach this time-worn twins topic in the only way that can guarantee impartiality (*i.e.*, freedom from professional bias) – with eyes wide open and hearts a-flutter; *i.e.*, naïvely.

## 2. Minkowski world vs. real world

Before all else, let us consider the reasoning by which relativists have convinced themselves of the “self-consistency” of their twin paradox analysis. This is the reasoning by which they invariably arrive at the obligatory benediction, “Thus we see there is no paradox.” Of course, self-consistency of a mathematical descriptive scheme, although of prime importance to the mathematician, is not the first concern of the physicist. The latter should have his critical faculties focused on how good the description is. He should be constantly looking over his shoulder at the real world, making “reality checks,” and he should accept no compromises in that department. If the physicist will not do this, who will? Self-consistency of the mathematics is a bonus – necessary, yet anything but sufficient.

Relativists generally rely on Minkowski diagrams to tell them how the world is. They insist that we live “in” Minkowski space. So, if we are to take relativity theory seriously, we must do the same for Minkowski space. The Minkowski diagram of the twin paradox is quite revealing. I will not reproduce it here, but it can be viewed by looking up “Twin Paradox” in Wikipedia. In brief, “simultaneity planes” are profiled as lines that slant oppositely for the outgoing and incoming traveler. These, expressive of the “relativity of simultaneity,” so intersect the vertical worldline of the stay-at-home

twin as to produce a Howling Gap in the middle of that worldline, such that the traveler attributes to the stay-at-home a sudden discontinuity (jump) of aging. This enables the traveler to attribute to the stay-at-home the clock-slowness demanded by the symmetry of the LT (*i.e.*, each twin's clock, during the limited intervals of genuinely *inertial relative motion*, runs slower than the other's), while also accounting for the large asymmetrical elapsed total time (*i.e.*, the greater net aging of the stay-at-home). The Minkowski diagram thus enables the relativist to have his cake and eat it. The *symmetry* of the LT is obeyed, while the observed *asymmetry* of twin net agings is also obeyed. The falsity of this pathway to asymmetry, though hidden from experts, will be evident to freshmen.

In the real world, as distinguished from Minkowski space, both above-mentioned features – the LT-dictated symmetry and the Howling Gap in Time – will be instantly recognized as counterfactual; that is, as lies. Neither clocks nor biological aging processes behave in any such capricious way. In the common course of Nature-as-we-know-it, jumps or gaps in time do not occur. Without exception, “time,” both in and between all systems of reference flows uniformly, continuously, and uninterruptedly. But the relativist, dreaming in Minkowski space, recognizes no problem with his aberrant description. He has simply transferred his allegiance from the real world to a mentally created space unrelated to the running characteristics of physical time-measuring devices. He is not looking over his shoulder at anything. Reality checks do not concern him. To have achieved mathematical consistency fully sates his scientific curiosity.

The price of the relativist's ardently desired result, the prediction of an aging asymmetry, was no more nor less than the telling of two lies. He had to tell the lie (1) that the stay-at-home's clock ran slower than the traveler's during the outbound and inbound rigorously

*inertial* legs of the traveler's journey, and he had to tell the lie (2) that the stay-at-home's age suffered a sudden jump, a high hurdle over the Howling Gap. (The first of these lies is as ludicrous as the second, since it indicates that the duration of the traveler's journey influences the running properties of the stay-at-home's clock.) These two falsehoods work smoothly together to yield the thing that the relativist prizes above jewels and beyond price, the *right answer*. Let there be a right answer anywhere in the space of possibilities, and he is on it like a duck on a June bug.

Do relativists acknowledge their toyings with factual experience to be "lies"? No, that would be poor public relations. They speak of what is "calculated," as if a calculated lie were a mitigated lie. Says Wikipedia: "The traveling twin reckons that there has been a jump discontinuity in the age of the Earth-based twin." In any physical theory, what is calculated or reckoned is what is predicted. There is no other reason for reckoning. If a Howling Gap in Time is calculated, then a Howling Gap in Time is predicted. That is what the LT is saying, and relativists seek no more reliable guide than the LT. Technically, the putative jump is indistinguishable from what in religion would be called a *miracle*; that is, an occurrence contrary to the common course of Nature. The only distinction is that the relativity professor's miracle is reproducible, whereas the priest's miracle is not. On every chalkboard in every institution of higher learning, the Minkowski diagram is displayed and the miracle is reproduced. Before the wondering eyes of credulous students worldwide the Howling Gap and the inertial interludes of slow-running of the stay-at-home's clock appear promptly on demand. For comparison, religious miracles may be typified by that of St. Crispin. He and his brother, after being tortured to ensure martyrdom, had millstones tied around their necks and were thrown into a river. The millstones floated. The brothers were then thrown onto a fire that did

not burn them. Finally, the stock of divine miracles being temporarily depleted, their heads were cut off; they then died and went to heaven. If there is a difference in degree of miraculousness between floating millstones and Howling Gaps in Time, I trust I will not be thought peculiar if I concede the edge to the latter. SRT, embodying a belief in specially potent miracles, thus qualifies as a specially potent form of religion, and is best judged in that light. In particular, given the history of religions, the obligation felt by SRT's acolytes to roast heretics (such as Herbert Dingle) falls neatly into place.

Let's digress briefly to examine how clocks behave in Minkowski space. The same Wikipedia article referenced above informs us that, "In Minkowski geometry the world lines of inertially moving bodies maximize the proper time elapsed between two events." This refers to any two point events on any straight worldline in Minkowski space. Suppose the stay-at-home inertial twin's straight worldline is bounded by points A and B, while the space traveler's journey is described by a dogleg consisting of two straight-line segments, AC and CB. Then for any other two points D and E freely chosen on segment AB the segment DE will be another straight-line segment describing inertial motion, identical to the inertial motion described by AB. So the proper time elapsed between event points D and E will be to that elapsed between points A and C as the scalar segment length DE is to the scalar segment length AC. This merely assumes that proper time is a state (of motion) function, so that the stay-at-home's proper time clock runs at the same (maximum) rate when traversing DE as when traversing AC. That is, in both cases the (inertial) state of motion of the stay-at-home's clock is the same, so its running rate is the same, both on the short DE segment and on the longer AB segment. On both these inertial segments the clock running rate has the extremal property; that is, the clock runs *faster* than on alternative (non-inertial) paths connecting the same end points. This is true for every choice of

DE on AC. From this it follows that the traveler's deduction previously mentioned – that the stay-at-home's clock runs *slow* on two explicitly predicted sub-intervals of the worldline AB, early and late in the journey (sub-intervals of rigorously inertial relative motion of the twins bounding the Howling Gap) – is false. A falsehood may be called a "lie," the irritating term I have chosen to use here. Relativists are in pressing need of irritation, since they passionately subscribe both to the lie and to the proof that it is a lie. Like medieval monks, they have too easy a life, preaching only to each other and the choir.

As for the Howling Gap itself, the state function assumption and the above deduction of the uniform running rate of the stay-at-home's clock on the whole of AB, augmented by all human experience, not to mention that much-despised element, common sense, makes a lie of that, too. So the traveler, by applying SRT and the LT, is led to explicit predictions about the behavior of the stay-at-home's clock that are flat-out lies. Predictions? Well, that is what physical theory is supposed to provide – what furnishes its reason for being. If a theory claims to be physical and makes physical statements, those statements are to be viewed as predictions. Were the experiment to be done and the necessary observations made, SRT's Minkowskian predictions would obviously be in direct conflict with such observations. No slow-running inertial clocks nor Howling Gaps would be observed. What would the relativists do then? They would simply look the other way and fall back on their mantra, that SRT is the most confirmed of all physical theories. The time-tested secret is in repetition. The principle of endless repetition has worked without a hitch for all practitioners from Machiavelli to Goebels. Throughout the history of media, media can be relied on to pitch in and render it infallible. All the media need to be told about the science is that there is a consensus of scientists. (The media depend upon science journalists who, as

Dave Barry<sup>[3]</sup> puts it, “majored in English and whose knowledge of science is derived exclusively from making baking soda volcanoes in third grade.”)

Because its account agrees with SRT and the LT, Minkowski space gives a deeper insight into the real world than does direct experience of the real world. Got that? If so, you are ready to join the academic mob – the gang of *right answer* copyright holders, the warm-fuzzy beneficiaries of consensus. Halleluiah and congratulations! Pass Go, collect \$11 and your Nobel Prize. Consider yourself officially processed, packaged, stamped, addressed, and mailed to the future; *i.e.*, higher educated.

### 3. Getting at causes: the first job of the physicist

Things that happen in the world are not caused by mathematics, regardless of what you may think you have learned from SRT. The latter treats the LT as if it were a necessary and sufficient cause of physical effects such as “time dilation” and “Lorentz contraction.” But the LT is just mathematics; it can play no causal role in anything. In physics, unlike mathematics, the thing described (any real effect) always has a cause. Always. No, I am not going to claim that Lorentz had the right idea in hypothesizing an ether to “cause” the Lorentz contraction. What I do claim is that physicists owe it to the fast-fading integrity of their profession to keep looking, past whatever mathematics they happen to favor, looking for physical causes. They should never surrender, for instance, to the idea that some physical effect is “just kinematics,” because that is tantamount to labeling it *just mathematics*. Modern cosmology suffers from an unchecked epidemic of such surrenders of physics to mathematics, as manifested by the reification of mathematical singularities, the elastic curving of SRT’s “spacetime,” etc. Thus mathematical creativity feeds upon

itself, beholden to physics for little more than the borrowed name of a name.

Consider this piano here. If I lean on it, nothing much will happen, because I somewhat resemble the “97-pound weakling” of the old Charles Atlas ads. But if you, who have not been watching your weight too carefully of late, lean on it, it is apt to move. You have *caused* it to move. The motion (kinematics) is *describable* by some mathematics, to be sure. But the mathematics is not the cause; you are the cause. Without the cause there would have been no motion and nothing to describe. These painfully elementary observations apply generically across the spectrum of physics. Usually, though, it is much harder to identify causes than in this example. But nobody promised the physicist a rose garden.

SRT rests its entire case on relative motion. (Despite unwarranted attempts to extend Einstein’s “relativity” to moral relativism and such, it is really a remarkably restricted theory.) If you look for more information within the theory proper, in particular for what *caused* the relative motion – what history brought it about, what acted how much on which participant to initiate that relative motion – you will not find out; not by consulting SRT or the LT. Supposedly, such ancillary descriptive features – factual histories – are not of central concern. They can be handled by hand-waving. Supposedly, what matters is a bunch of mathematics. Don’t believe it. That’s not where the physics lies. Your higher educators can’t wait to hustle you into the mathematics; but the real physics is in the leaning on the piano – in the physical cause of the observable effect.

In searching out the cause of any effect, the first step is to ascertain the phenomena that invariably precede or accompany that effect. That is only the first step. It is usually easy to find an abundance of such candidates, and, although they all feature on a list of suspects, no

more than one is likely to be rightly identified as “the cause.” The second step is therefore to undertake a winnowing process.

Let’s illustrate by seeking the cause of time dilation. To enunciate this simple goal introduces a brand new topic in relativity theory, not to be cribbed from Einstein. To sharpen our thinking, let’s focus on a specific model, the CERN muon experiment<sup>[1]</sup> of 1977, in which a cloud of muons was put into high-speed circular orbit, with a time dilation factor of  $\gamma \cong 29$ . This is, of course, closely related to the twin paradox. Let us commence the winnowing process. We seek a cause for this clock-slowness phenomenon, and first-off some experts such as Feynman<sup>[2]</sup> have suggested *acceleration* as what distinguishes the twins or what causes the circling muons to have half-lives 29 times longer than the lab-stationary muons. True, the slow-running clocks in orbit have in all cases been accelerated. So acceleration is a legitimate candidate. But it has a number of flaws. To name only the most obvious, acceleration is a vector; it is changing from moment to moment as the muons circle around; yet the muon clocks show no evidence of anything but a uniformly slowed scalar running rate.

So, what fits that? Not velocity, either, but translatory speed  $|\vec{v}|$ . But that also is not quite what we are after, since an absolute value lacks the desirable property of analyticity. That is offered by the scalar quantity  $v^2 = \vec{v} \cdot \vec{v}$ . Now we are getting somewhere, since we recognize  $v^2$  as having a physical pedigree. It enters into the classical kinetic energy  $mv^2/2$ , and also into both the relativistic time dilation factor  $\gamma = 1/\sqrt{1-v^2/c^2}$  and the relativistic expression for high-speed particle kinetic energy,  $m_0c^2\gamma$ . The search is narrowing, since experience teaches that kinetic energy, both classical and relativistic, plays a central role in physics. But surely this is not the whole story. What about *total* energy, which adds potential energy

to kinetic? Could changing total energy of the particle be the cause of its changing timekeeping properties? This idea is very attractive, since any change of a clock's running rate is invariably accompanied by a change of that clock's total energy state. Let's make a reality check on potential energy. The easy thing to check is the influence of gravity. When I raise a clock in the Earth's gravity field I move it farther from the Earth's center, hence I move it into a weaker gravity field. What happens?

In lifting it I have done work on the clock, hence have increased its positive potential energy. But wait – what says the Global Positioning System (GPS) evidence? Has my clock's running rate been slowed by this work I have done on it, as would be the case if I had done work to increase the kinetic part of its total energy? No, quite the contrary. The reality check fails. GPS evidence shows that the clock in orbit will run *faster*, not slower, if left alone to show proper time. So, what to do? Very simple – just change the algebraic sign of potential energy. And what conceptual entity in classical mechanics accomplishes that automatically? Actually, there are two, the Lagrangian,  $L = T - V$ , and the descriptive quantity known as

“action.” The latter has a time integral form,  $A = \int_{t_1}^{t_2} a dt$ , where

$a = \sum p\dot{q} = T - V + H$ ,  $H$  being the Hamiltonian or total energy, a constant in conservative situations. Since a *time integration* over changing  $v^2$  values is appropriate to physical problems involving change of motion state, action is the preferred quantity to choose. So, by simple ratiocination, we have gained the recognition that action change (positive increase of action) triggers time dilation (clock slowing). But if potential energy does not change, then simple kinetic energy change is an adequate causal candidate, and this is what

currently available laboratory (CERN) evidence<sup>[1]</sup> supports. That *action*, rather than total energy, is the more generally preferred criterion is confirmed by GPS evidence, which shows for present satellite orbits that the effect on clock running rates produced by gravity potential energy change is about six times greater than that of the kinetic energy change and acts oppositely to kinetic energy (to speed clock running rates), in agreement with the sign choice dictated by the action definition.

Is “action” change, then, the physical *cause* of time dilation? It is certainly not the root cause, which lies in Nature and is only *described* by action state change. But by that token it is probably not within the reach of mathematical physics to do much better in identifying a quantifiable causal agent. (As for the cause in Nature, it is tempting to think of the enhanced sluggishness of a clock’s running rate as attributable to the accompanying mass increase of the clock by a  $\gamma$ –factor. Such a kinetic effect, as well as the known gravity effect, is automatically comprehended in “action.”) Action is certainly a preferable criterion to cruder ways, such as acceleration, of introducing a physical asymmetry into the twin problem. But even the crudest such attempt, as its advocates seem incapable of recognizing, flatly denies the symmetry of the LT and its inverse, hence blindly gropes toward a realization that LT-based kinematics is not physics, and that bare kinematics can never *take the place* of physics.

Action changes being asymmetrical between the famous twins, it is clear in the absence of gravity change that the twin that has had positive work done on it (to change its action state) is the one that stays young. Such asymmetry is directly contradictory of the manifest symmetry of the LT and its inverse. SRT contains no clues to action changes. Hence (without the descriptive narrative I term “hand-waving”) it cannot tell us which of the twins stays young or which clock runs slower, consistently with the uniform aging rates of

proper-time clocks and twins subject to uniform physical conditions. Being a genuine kinematics, SRT, honestly conceived as founded upon purely relative motion, lacks the necessary information. Suppose the relativity professor's hands are tied, so he cannot wave them (for purposes of identifying which twin was "moved"). Then the resulting unfudged SRT is unqualified to serve as a physical theory. Action changes are physics, and physics should come before kinematics. But the friends of SRT just will not sit on their hands. They feel compelled to supply whatever extra-kinematic information is missing – without even being aware that they are supplying anything extraneous to their adored theory. We should all have friends like that.

The great pity in all this is not the inadequacy of SRT as a physical theory but the myth of its enduring perfection. That myth is what blocks all possibility of improvement, not to mention any chance of second thoughts. The problem is endemic in modern physics, the same thing being equally true of what we are pleased to call Maxwell's equations. The making of myths-of-perfection has become a settled habit of physicists and scientists in general in our era, a cottage industry. Such myths serve an important professional purpose — that of labor-saving. They enable scientists to agree on never having to look back, while congratulating themselves on their open-mindedness. Einstein himself called attention to the mythical nature of the perfection of quantum mechanics, but that had no effect on the *Zeitgeist*. The physics Establishment felt no need to circle the wagons. Even the most revered challenger is impotent against "consensus," the fixed determination of a majority not to rethink its position. Consensus, like poverty, will always be with us, in fair climate and foul. It embodies the democratic ideal, a coagulation — a clotting — of the common mind, which fits the common politics but has nothing to do with science. In the past it supported witchcraft; today it

supports anthropogenic global warming (aka “climate change”), breathes physics into mathematical singularities, supports clever dodges such as “second quantization,” and promotes other pseudo-scientific follies without end.

A sure identifier of the most popular class of such follies is that they are marked by political correctness. Thus the up-to-date authorities who treat the LT as adequate for analyzing the twin problem invariably identify the sex of the audacious astronaut as female. She is “Alice,” straight out of the Dilbert comic strip. In light of the space traveler’s superior resistance to aging, however, I prefer to think of her as “Blondie.” Alas, political correctness is notoriously treacherous. The text-writers would surely break a leg (“Hals- und Beinbruch”) to rectify their sexual favoritism if Alice’s stuck-in-the-mud stay-at-home partner Bob were stipulated to be black.

#### **4. How does relative motion come about?**

Consider two bodies, A and B, at relative rest. Let one of them be set into motion at constant speed  $v$ . The relative speed, measured by the single parameter  $v$ , is then known to us. We are now ready to turn the crank, being possessed of all the information granted us by Einstein’s SRT, everything needed to exploit the full extent of that theory’s analytic capabilities. As we know, SRT is a theory built upon the presumption of Gedanken inertial systems in eternal uniform motion, two of which permanently coincide with our relatively moving bodies A and B. Does this mean that we know all the physics of the situation? Certainly not. For instance, which body was pushed on to establish the relative motion? Was it A or B? Whichever answer we give, the parameter  $v$  is the same and the co-moving inertial systems are the same. So, the bare-bones theory, embodying nothing more than the mathematics of the LT, does not specify an answer, and

yields in both cases an identical analysis. Yet is not a definite answer a part, and an important part, of the “physics”?

Of course it is. If the masses of A and B differ, for instance, we had to push harder on the more massive one, if that was the one we moved to establish the observed relative speed  $v$ . How hard we had to push to establish  $v$ , how much we had to sweat, depends on which of the two bodies we pushed on, and that is evidently an essential part of the physics, and an important part of the causal story behind the establishment of relative motion. Real physics is manifestly involved, insofar as the sweat is real. There’s always plenty of physics required to answer the query, *How does relative motion come about?* But all the physics contained in that question is *missing* from Einstein’s SRT. Please note: Important physical information is totally absent, vanished, *spurlos versenkt*. SRT is *not*, and never has been, a full physics. We have merely for a century chosen to treat it that way, even to *treat* it as the basis for modeling a new species of “world,” progenitor of *worldlines* and all that. And when it won’t “treat,” we make excuses for it and add codicils to it, as if we were lawyers or politicians instead of physicists. Pardon the baby talk. It is my way of trying to communicate by thumps and taps with a profession that for a century has resisted emergence to babyhood, and seems determined to stay in the womb for the next thousand years.

The twin (or clock) problem is very much a problem of physics. Without exception, *the experiments bearing on it are all genuine physics*. How do we know that the physics missing from SRT will not be the physics needed honestly to *resolve* the twin problem? We don’t *know* it. But we have dedicated a century of indefatigable efforts to behaving as if we did; *i.e.*, to making Gedanken bricks without Gedanken straw.

The textbook resolutions of the twin paradox generally smuggle in some form of physical asymmetry not native to SRT itself. For

instance, Langevin's 1911 explanation rested upon the assertion that "any change of velocity, or any acceleration has an absolute meaning." That may well be true, as a factual statement about the physics. The relevant question is, is this fact part of a theory that recognizes only "relative motion" (and therefore does not recognize the Machian aspect of the physics)? No, it is an attempt to dress up such a theory by covering its nakedness with extraneous physics-related attributes missing from the theory proper. If such *ad lib* and *ad hoc* dressings-up are to be allowed, based on the introduction of true-but-inadmissible evidence, the theory becomes not only not falsifiable but not even well-defined. And what if success attends the search for a physical cause of physical asymmetry? Does such success on the side of physics prove anything on the side of kinematics, apart from the irrelevance to any theory of the mathematically symmetrical LT and its attendant fantasies such as the Howling Gap?

Another textbook example: Taylor and Wheeler<sup>[4]</sup> altogether *eliminate acceleration* from their analysis by substituting for the usual single traveling twin two travelers, an outbound one and an inbound one. When these two, traveling in opposite directions, pass each other they are the same age ... and so on. The clock of the returning traveler then shows the elapsed proper time difference between the events of Earthly departure of the first traveler and arrival of the second. But no consistent story is sought or can be told by the LT about how a single clock co-moving inertially with the stay-at-home could run at a uniform (fastest) rate, without jumps or interludes of slow-running, between those two events. The existence of an acceleration-free version of the problem shows at once that acceleration cannot be the key to its resolution (and that in turn shows the spuriousness of claims of the *necessity* to bring in General Relativity Theory and the Equivalence Principle to describe acceleration-that-is-not-there by means of an "equivalence" to

gravity-that-is-not-there). Einstein's 1918 resort to that line of reasoning merely shows the *gravitas* of the problem.

This acceleration-free version of the twin problem does not evade the central criticism of all analyses based on SRT: According to the view of SRT expressed here, the mere initiation of relative motion between stay-at-home and outbound traveler that starts off the whole "space-traveling" adventure lies outside SRT proper. If you leave the "first traveler" at rest and push on the "stay-at-home," it is the latter who stays young. The relative motion between these two is established how? By changing the *relative motion* state of which individual? That is not answerable except by arbitrary stipulation – part of the story-telling – in other words by the math-free narrative I have called *hand-waving*. Motion *state-change* is not quantifiable within an LT-based kinematics. It requires by definition a dynamics, or, more broadly, a physics. To gain full understanding of a physical situation requires putting the physics first.

How are contrary conclusions reached? Simply by supplying gratis the information about physics not native to SRT. By forgetting, that is, what Einstein's theory actually is, and what its inherent limitations are. Be reminded once more: When there is relative motion between two objects, there is no purely kinematic way of knowing how that relative motion was produced. Any claim to know this is based on the tacit introduction of information extraneous to any and all kinematic theory. Such is by definition the nature of relative motion and of any kinematics based on it. Such is the nature of SRT. That is as far as the LT takes us. To take it farther is to muddy the waters by mixing in a narrative that partakes of science fiction. For a hundred years scientists have allowed their destinies to be guided by science fiction – and have dutifully chimed in with extra chapters of the narrative. Let's innovate by making a supreme effort to recall what real science is. Does that seem too much like work? Come, gentlemen and

scholars, arbiters of scientific taste, academicians all, let's you give it the old college try. Come, throw caution to the winds! Scorn the petty rewards of this world – the tenure, the grants, the Nobel Prizes, the TV appearances, the invitations to contribute to Wikipedia, the envy of the naïve masses, the warm-fuzzy feeling that rewards allegiance to a consensus ... Unless you have something better to do.

## 5. The physics of the twin paradox

Herbert Dingle, one of the few physicists of the last century blessed (or cursed) with both gumption and courage, reached in reference to the twin problem a final conclusion before being professionally ostracized: *that SRT was not physics*. This sounds at first like a foolish, even a meaningless, charge, and his claims accordingly earned universal condemnation. But consider:

It turns out, as often happens in such cases, when a man takes a stand against a profession, that he is right. The profession, a consensus of sheep, does not think; it is therefore not necessarily smarter than a man who does. In the twin problem the real asymmetry needed to account for the differential aging enters through identification of which twin (A or B) was pushed upon in the process of creating the relative motion. That is, which twin *changed its kinetic energy state*. Keep your eye on energy state changes. Energy, or its action counterpart, is what matters, because one always gets the authentic right answer from that criterion. *From SRT one can expect to get the right answer only half the time, by tossing an unbiased coin.* *Proof:* The timelike portion of the “boost” LT from inertial system  $S$  to  $S'$  asserts that

$$\Delta t' = \gamma \left( \Delta t - (v/c^2) \Delta x \right),$$

where  $\gamma \equiv 1/\sqrt{1-(v/c)^2}$  and the  $\Delta$ -quantities denote intervals between any two point events of timelike separation. If we interrogate a clock at rest in  $S$ , so that  $\Delta x = 0$ , then  $\Delta t'/\Delta t = \gamma > 1$ , meaning that the clocks at rest in  $S'$  (which all run at the same rate) all run *faster* than any of the  $S$ -clocks. The inverse LT from  $S'$  to  $S$  asserts with equal assurance that  $\Delta t = \gamma(\Delta t' + (v/c^2)\Delta x')$ ; whence, if we interrogate a clock at rest in  $S'$ , so that  $\Delta x' = 0$ , then  $\Delta t'/\Delta t = 1/\gamma < 1$ , meaning that all clocks resident in  $S'$  run *slower* than any of the  $S$ -clocks. So, ... faster or slower? Which system's clocks are in fact the laggards? Neither Lorentz nor Einstein can help. If you happen to have a coin on you, this question belonging to the science of physics can be settled by applying the science of numismatics, *q.e.d.*

Actually, when the algebraic signs are chosen to agree with empirical (GPS) evidence, as we have seen, it is not energy itself but *action* that is the proper universal criterion. The space traveler that registers the greater positive change of action (in making the transitions of action implicit in the journey, governed in detail by the Principle of Least Action) is the one whose clocks record the least elapsed time between given events (run slowest). That's the physics of it. If attention is paid to the physics, no coin tossing is needed.

If this is true, as I believe it to be, then we are employing in our recommended approach to solving the twin problem some of the physics that was left out of SRT; that is, physics associated with how a state of relative motion is established, rather than with the relative motion state *per se*. So, which did we outfit in astronaut's togs, A or B, Alice or Bob, as a preliminary to establishing their relative motion? Information bearing on that choice is not to be gleaned from SRT *sang pur*. SRT concerns itself with a Gedanken relative frame-motion

established sometime around 1905 and persisting ever since, world without end. And, without the vital information as to whether A or B was pushed-upon to change its energy (or action) state, we do not have a symmetry-breaker consistent with our experience of the uniform running rates of proper-time clocks. All we have is the wish ... which proves very powerful, though not very persuasive to a doubter. But, then, all skeptics are crackpots. It's an axiom – ask any mainline physics journal editor or other expert in the identification of witches or heretics.

The experiments all accord perfectly with the above view. The CERN muons<sup>[1]</sup> that stay young are those that have had work done on them to boost their kinetic energy – consequently their action state has undergone a positive increase. Any fiducial muons at rest in the laboratory maintain their fast-running habit while staying permanently at rest in an unaltered action state. Those GPS clocks that have had work done on them by putting them in orbiting satellites are the ones that would (apart from the effect of gravity) run slow if we had not deliberately contrived a compensatory clock-rate speeding-up in order to cause them, when in orbit, to run at the same rate as clocks at rest on the Earth's surface. And so on. One can't even talk about the experiments that have been done without using *physics* culled from what SRT leaves out. Every experiment with proper-time clocks shows a genuine rate asymmetry, which exhibits the slower-running clock as the one that has experienced a greater positive increase of its action (or its kinetic energy, if no gravitational or other potential energy changes are involved). Those are the physical facts.

At this point a horrid thought springs to mind: Has all our talk about asymmetry violated the relativity principle? At a hasty glance it might seem so, since the relativity principle is often carelessly interpreted as implying perfect *symmetry* among inertial systems. But

more careful thinking is warranted. It is important to note the exact wording of a valid relativity principle:

*The form of the laws of nature is invariant under changes of inertial system.*

This is an assertion of *formal invariance*, not of numerical invariance. It allows for exceptions to numerical invariance on the timelike side. Formal invariance would demand clock running rate invariance only if time flow rate possessed some absolute numerical value or meaning – which it does not. Newton’s laws of motion illustrate the actual situation: In Newton’s second law the time parameter  $t$  can be replaced by  $kt$  at will, without altering the physical validity of the law. (This recognition Newton himself generalized as his Principle of Similitude.) The idea of a universal “time flow rate” that is preferred in nature is without logical support or physical substance. Hence the relativity principle in the above form is valid even if clock running rates vary with inertial system and with history of clock changes of action state, whether kinetic (motional) or potential (gravitational).

The known inexactness of the proper time differential  $d\tau$  implies that clock phases (elapsed time readings) are path dependent; but clock *running rates* (frequencies) are an entirely different matter. These, as we have noted, may be assumed to be *action state functions*, for clocks originating in a given state of motion and gravity. Such clocks will, after arbitrary travels, always resume their prior running rates, when returned to a prior state of motion and gravity. If clocks can be assumed to originate independently in different systems, however, it is conceivable that such clocks might obey different state functions. The verifiable running habits of actual clocks necessarily take priority over the character of an abstract “time.” They come first in defining the *laws of nature*. But the latter, once known, can be used

to correct clock running rates so as to define a simplest kind of abstract time (see<sup>[7]</sup>).

## 6. Summation

SRT seemingly aims to provide a new physics, even to reveal all we need to know about a new-Age four-dimensional Minkowskian “world” we are privileged to inhabit. But by its most basic terms of reference, founded upon nothing more substantive than relative motion, SRT can neither constitute nor comprehend the full physics of our specific world, the one we actually live in. A major portion of the physical story is overlooked – the portion answering to the question: *How is relative motion established?* That is a vital part of the physics. It is a part deliberately omitted from SRT, a kinematics that in its canonical form (governed by the LT) is therefore not competent to give straight answers to questions of the kind raised by the twin paradox. This accounts for the staying power of that puzzle ... as well as for the staggering variety of “resolutions” to be found on record in the literature (a mountain dwarfed, one may speculate, by the totality of resolutions rejected by journal editors); all of which by its very existence implies a general recognition that Einstein’s original SRT-based 1905 resolution<sup>[5]</sup>, and also his later 1918 one<sup>[6]</sup> based on General Relativity Theory (GRT), were both inadequate.

Further, this calls into question the adequacy of GRT as physics, since GRT is acknowledged to inherit all the structural disabilities of SRT through having SRT as its flat-space limit. Moreover, GRT’s basic building materials – a fictitiously symmetrical “spacetime” and purely relative motion – are just as lacking in physical adequacy in GRT as they are in the SRT context. Stand back, then, from all this and recognize that higher geometry – all those mind-boggling, world-beating, four-index tensor symbols of the *Mathematical Illuminati* –

boil down in the simplest limiting case to a mere kinematics ... and a shaky kinematics at that, susceptible (as we have seen, with 50% probability) to wrong answers. Relativity theory lavishes high-quality mathematics upon no-quality physics to produce low-quality kinematics, nothing more. I wish to emphasize the inherent folly of building a *world* upon any kinematics, even a sound one. To the wondrous subtlety, variety, and complexity of the actual world we live in we owe, as scientists, the respect implicit in the recognition that nothing less than a physics, the most basic and comprehensive of the sciences, will do for a descriptive foundation ... as the people who call themselves physicists, and are charged with the welfare and preservation of the discipline, have strangely and traitorously forgotten for a century.

We, the physics community, have treated as if it were a full physics a theory that is manifestly nothing of the sort. Why have we done this? Possibly because we have simply been stunned by the virtuosity of Einstein's performance, the *annus mirabilis* and all that. Stunned out of our wits for a century, the whole lot of us? What amazing paucity of independent thinking underlies our basic science! It seems beyond belief. Yet, if (owing to the indelibility of the historical record) it must be believed, why must the good times and good fellowship be limited to a century; why not a millennium, like Ptolemy's astronomy – perish the thought? That was the first instance of a universal scientific consensus – something we are told we ought to be striving for nowadays, like good little automata, in order to attain a really credible (“settled”) science that can be *used* politically to impress other sets of automata – the U.S. Congress, the National Science Foundation – in order more efficiently to milk them of tax dollars.

Finally, the resolution of the twin paradox is that it cannot be resolved within SRT. (Einstein himself explicitly enunciated<sup>[6]</sup> exactly

this conclusion in 1918 when touting his General Relativistic resolution of the twin problem. In that connection, GRT also cannot provide a resolution, unless you are willing to fill all space with a purpose-built gravity field that is not there – in order to get the famous self-justifying *right answer*. As long as SRT is the flat-space limit of GRT, neither will be physics. “Geometry” lacks vital informational elements of physics. That physicists have been fooled on this point is merely evidence of creeping incompetence within the profession.) A workable resolution will require a new explicitly physical theory, not subject to the crippling limitations of a relative-motion kinematics. It will have to be built from scratch, based on recognition of the genuinely physical timekeeping asymmetry attendant on action state-changes. Exposition of such a total reconstruction, based on universal Galilean invariance rather than universal Lorentz covariance and beginning with Maxwell’s equations, is beyond the scope of this paper, but has been attempted in book form<sup>[7]</sup>.

## Acknowledgment

Nick Percival has pointed out to me logical problems associated with the assumption that the running rates of clocks originating in different systems share a universal (action) state function.

## References

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