GPS Evidence Against the Relativity Principle

"There are more things in heaven and earth, Horatio, than are dreamt of in your event calculus."

– Wm. Shakespeare (amended)

Abstract. The Global Positioning System (GPS) compensates the running rates of its atomic clocks for their orbital motion by speeding them up so as to cancel the relativistic time dilatation. Such compensated clocks, when in orbit, run in step with each other and with an earth-surface Master Clock. This means that a naturally-running proper-time clock placed in orbit without compensation for its motion must run objectively slower than its naturally-running counterpart on earth. There is consequently a factual clock-rate asymmetry between two inertial systems that violates the ordinary understanding of the relativity principle. In brief, clock rates represent physical observables not delimited by specific point events; therefore they do not conform to an event calculus and are not consistently described by special relativity theory. To probe this matter empirically an experiment is proposed involving light-speed measurement in orbit with compensated and uncompensated clocks.

Prologue

Where clock rates are concerned, special relativity theory (SRT) is an amphibian between appearance and reality. It needs this quality to survive – and it is a survivor. (Authorities today inform us that the theory is not a theory but a fact. Facts are not falsifiable. SRT being not falsifiable, it is clear why it *survives*.)

The relativity principle, as customarily understood, demands a symmetry of asymmetry – the clocks of two inertial observers each running slower than the other. To avoid an infinite logical regression to nonsense, SRT therefore needs clock rates to be *appearances*. Whereas, to earn credit for predicting the observed asymmetrical aging of muons (circling and stationary in the laboratory), SRT needs clock rates to be *real* and objectively asymmetrical. For it is manifest that the clock of a circling muon traveling at constant speed must "age" at a uniform rate … and, since the net effect of the journey is *observed* to be a staying young, it must be that this staying young was a process taking place at a uniform rate throughout the uniformly circular motion.

This can only mean that the SRT stay-at-home observer's prediction of uniform rate-slowing of the traveler's clock describes not an appearance but a reality – a factually real asymmetry. However, this conflicts with the "appearance" view of clock rates, dictated by the relativity principle. So, which shall it be? Symmetry or asymmetry? Appearance or reality? Agreement with principle or with observation?

SRT, of course, has a response – indeed, one for every shade and climate of authoritative opinion. Are we to believe, for instance (following Feynman), that the asymmetrical element in the muon or twin situation, *acceleration*, acts causally to convert appearance to reality? This parameter enters nowhere explicitly in the theory … it appears logically as a *deus ex machina*. Its only function is to save not the phenomenon but the theory. Pauli postulated *no explicit effect* of acceleration on timekeeping … and the muon data validate that for accelerations up to $10^{18} g$. Yet, here we are blandly alleging the most profound effect possible – conversion of appearance to reality, theoretical symmetry to factual asymmetry. That's a heavy load for a non-load-bearing member of any theoretical structure to bear.

Other apologists for SRT (following Wheeler-Taylor) totally reject the acceleration mechanism and cite acceleration-free versions of the twin paradox. They use SRT's event calculus (equivalent to a Minkowski spacetime diagram) to show that clock *phase jumps* properly account for the asymmetry of elapsed time observations. But they never explain how these discontinuous phase jumps fit with the necessarily uniform running rates of all clocks throughout the journey – implying *unobservability* by anybody of any clock rate discontinuities whatever. Neither actual clocks nor physical nor biological processes behave discontinuously in nature. The stay-at-home twin cannot reset his biological clock to accommodate the phase jumps needed to explain elapsed times. That clock must run *inconsistently* – slow to match the traveler's SRT analysis, fast to match the facts. The relativist is not concerned with describing all observable aspects of physics, only with describing whatever fits his calculus of point events.

The upshot is that clock rates (or biological aging, etc.) fail to fit an event calculus of any kind. The very concept of clock rate

implies not a point event nor pair of events but a *process* sustained in time for an unspecified duration at an indefinite epoch. Yet SRT's problem with clock rates is more poignant still. When winkled out of the point event mold and considered as physical observables in their own right, clock rates *are* described by SRT and *described inconsistently*. That is the bitter pill supporters of the theory can never swallow.

But help is on the way … with a good chug-a-lug of observational data from the Global Positioning System (GPS) it is possible that some of the more perceptive and strong-stomached of them may be able to choke down that pill … and perhaps even hold it down – though it may cost them tummy trouble at job-hunting time. (Do you suppose there is a Dean or Physics Department Sachem in America who would hire any soul that harbored the faintest doubt about SRT? Know-it-all Think-alike Academia USA appears to be marching in step under banners – announcing slogans that make Chairman Mao's cultural revolution look like the blooming of a hundred flowers of intellectual diversity. One of these banners proclaims SRT an eternal truth. Another proclaims cold fusion an eternal falsehood.)

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1. The GPS and Relativity Effects

An object falling freely in a gravity field behaves in some ways as if gravity were locally "turned off." General relativity theory describes its motion by a geodesic, which is (roughly speaking) a path of least curvature. Such motion is referred to by theorists as *inertial*. It is seen as a generalization to the real world of the idealized straight-line uniform "inertial" motions of Newtonian mechanics and of special relativity theory (SRT), from which gravity is absent by definition. (An intermediate concept is Galilean inertial motion, which takes place uniformly in a straight line on a frictionless, flat gravitational equipotential surface. On earth, such a surface is termed "horizontal.") Inertial motions are significant for kinematic theory, in that they play a role essential to the relativity principle, a major building block of SRT.

A clock of the Global Positioning System (GPS) when in orbit is in free fall – hence it is at rest in a locally inertial system and its motion is inertial. Two independent relativistic effects on such clocks are recognized and compensated for by the GPS. There is an effect of location in the gravity field and a separate motional effect of "time dilatation" by a factor $\gamma = 1/\sqrt{1 - v^2/c^2}$, where *v* is clock velocity with respect to some fiducial state of (quasi-inertial) motion, taken to be that of the mass center of a non-rotating earth. The effect of location reflects the fact that clocks run slower the deeper they are placed in a gravity field (*i.e.*, the stronger the field due to source proximity). This means that when a GPS clock is moved from the earth's surface into orbit it runs slower due to time dilatation but faster due to location change (being less deep in the earth's gravity field). In GPS practice, the location effect is several times larger … but for purposes of theoretical discussion here we shall treat it as if it were absent, all gravity effects on clock rates being nullified by compensations separate from those to be discussed. (This is legitimate, since the two effects are small and independent, hence they superpose linearly.) Thus attention will be confined here exclusively to the phenomenon of time dilatation produced by clock motion.

2. How the GPS Compensates for Clock Motion

A naturally-running clock left to its own devices, regardless of its state of motion, by definition tells what is called *proper time*. In SRT the proper-time interval between two events plays the central role of an "invariant" quantity, the same for all observers. The engineers who designed the GPS recognized something completely alien to the thinking of modern physicists, namely, that physical description can be markedly simplified if one disregards proper time and forces clocks in different states of motion – hence running naturally at different rates due to different time dilatations – all to run at the same rate. That way, they can all "talk to each other" and mean the same thing by "time."

This simple concept of forced rate equalization, which amounts to treating naturally-running (proper time) clocks as fallible measurers of "time," just as thermometers are treated as fal-

lible measurers of temperature, has never entered the physicists' universe of discourse. It does not feature at all in their thoughts about *time*, which are largely circumscribed by the theories of Einstein – wherein clocks are never rate-altered by human intervention. "Frame time," the same throughout a non-rotating, uniformly-translating infinite inertial system, does enter SRT, but it is the proper time of each of an array of clocks at rest there. Orbiting clocks are not at rest in any such system. Lacking guidance from the special theory, then, how did the engineers proceed?

Confining attention to the GPS atomic clocks, we note that in such clocks a cloud of cesium atoms is irradiated so as to stimulate in some of the atoms a hyperfine transition at frequency N_0 cycles per second. The resulting sharp resonance provides a stable timekeeping reference. Thus the *second* of time can be considered to be defined as some large integral number N_0 of "atomic oscillations" occurring per "second." This is in effect the second of earth-surface proper time. (For simplicity of exposition we shall identify this second with that measured by the GPS Master Clock, ignoring the fact that such an earth-surface stationary clock itself needs compensation for earth spin.) The GPS engineers reasoned that if this same cloud of atoms were placed in orbit at speed *v* relative to a chosen fiducial reference state of motion (which, as noted, they took to be that of the mass center of the earth) then those atomic oscillations would be slowed by the time dilatation factor $\gamma = 1/\sqrt{1 - v^2/c^2}$ due to the relative motion. To correct for this anticipated slowing, they pre-compensated this motional effect by *speeding up* the clock to be orbited. That is, they set it to run at a rate increased by the factor γ. This was done in the simplest way by redefining the "second" to be a reduced number $N_0' = N_0/\gamma$ of oscillations of the cesium resonance.

For purposes of discussion, we could picture the "clock" as serving a dual purpose – containing two counters of the basic oscillations, one set to register a "natural" proper-time second every N_0 oscillations, and the other set to register a "compensated second" every N_0' oscillations. Since $\gamma > 1$ and $N_0' < N_0$, such fiddling causes the compensated clock to run faster (register more

"seconds" of elapsed time during a given interval of natural time passage) than the uncompensated (proper-time) clock.

Obviously the compensated clock, while located on the earth's surface, represents an anomaly for which SRT does not prepare us. For instance, if it were used there to measure the speed of light, the resulting measurement would yield a number different from *c*. Such clocks are beyond the pale. They are unclocks – forbidden to exist by the second postulate of SRT. That theory would require us to find a new name for them other than "clocks." And what they measure could not be called "time."

However, when they are placed in orbit a magical thing – a thing politically incorrect but eminently useful – occurs. By means of radio contact with the earth-surface Master Clock, all these compensated unclocks are found to run at the same rate as the Master! The effect of their motion on timekeeping has been nullified. Each orbiting clock of the GPS, individually compensated for its particular orbital motion by its own γ-factor, runs at the same rate as all the others and as the Master Clock on earth. Each clock "sees" all the others as running in step with itself. This, of course, is exactly what the engineers aimed for. But we readily discover that the success of this clock compensation scheme plays hob with SRT … in fact, with the relativity principle itself, the rock on which SRT is founded.

3. Timekeeping Asymmetry

For the fact that each compensated clock runs faster than its corresponding uncompensated (proper-time) clock, which was true on earth before launch, remains true after launch: N_0' remains less than N_0, since these are invariant numbers, independent of the clock's state of motion. And since the GPS data show that the orbiting compensated clocks all run at the same rate as the Master Clock, which tells earth-surface proper time, it must be objectively true that *orbiting proper-time clocks run slower than earth-surface proper-time clocks*. Thus the GPS is telling us that the slow-running of orbiting clocks is not an "appearance" nor a "perception" of the earth-surface observer, but a fact verifiable by any

observer. The natural (proper-time) running rates of these clocks are asymmetrical as a matter of physics.

Let us pause to formalize this argument. SRT says (from the earth system viewpoint) that the earth-surface uncompensated clock X runs faster than the orbiting uncompensated clock Y. (We may symbolize this as X > Y). In contradiction of this, it says also (from the satellite viewpoint) that Y > X. Both these theoretical statements cannot be objectively true, regardless of "viewpoint" – provided we accept clock rates as *physical observables*, implying that all viewpoints must agree on them. GPS evidence supports the earth system view. It shows that the orbiting compensated clock Z runs in rate synchronism with X (Z = X). And since Z is by definition (see above) set to run faster than Y (Z > Y), it follows that X > Y. This supports the objective factuality of the earth system view, and conflicts with the relativistic symmetry (*both* X > Y and Y > X) demanded by the relativity principle.

4. Motional Relativity Fails Between Inertial Systems

Now we recall that orbiting (free-falling) clocks are at rest in locally inertial systems. But what about earth-surface clocks? For many purposes, such as Einstein's famous "train" example, such clocks are treated as effectively "inertial," as long as they stay on a (horizontal) equipotential surface of the earth's gravity field. But how is the rate of a clock affected by whether its rest system is inertial or not?

Let us digress a moment to answer this question. Consider an earth-surface clock, such as our Master Clock, to be momentarily dropped – that is, put into free fall. We know that an object in free fall behaves as if gravity were locally "turned off." As soon as released into free fall, the clock becomes instantly inertial (*i.e.*, at rest in a locally inertial system), but its initial velocity is small, $v^2 \ll c^2$, consequently $\gamma \approx 1 + v^2/2c^2$ remains for a short time interval approximately 1, and there is negligible departure from the original gravitational equipotential, so the clock's rate is not instantly affected. We may conclude that whether a clock is supported in a gravity field or not has no instantaneous effect on its

running rate. Therefore, in regard to its running rate the Master Clock, whether dropped or not, can be considered inertial.

As stated, we know the orbiting clock to be inertial, since it is permanently in free fall. Recalling our conclusion above that orbiting proper-time clocks run slower than earth-surface proper-time clocks, we thus have a situation in which two *inertial* naturally-running, uncompensated, proper-time clocks (Master and orbital) run asymmetrically, at objectively different rates. This means that there is an observable physical quantity (natural or proper-time clock rate) that must be assigned different numerical values in different inertial systems. Thus the different inertial systems are not equivalent for measurement purposes. This violates the relativity principle (RP) as currently understood.

At least the spirit is violated. The letter is not necessarily violated, depending on how you read it, since SRT need not recognize clock rates as observables, but only point events. By means of its event calculus, introducing clock phases and the Lorentz contraction of lengths, SRT correctly predicts elapsed times but leaves aside rates. If rates are considered unobservable, the relativity principle is obeyed. My claim of RP violation is based on the counter proposition, that clock rates are in fact direct physical observables in their own right.

Note that when the Master Clock is dropped all clocks of the GPS become instantaneously "inertial" in the general relativistic sense of the term. Therefore none is distinguished in principle from any other. Thus the *compensated* (tampered with) clocks are all *equivalent*, none preferred, all being in various states of (inertial) motion that can be considered arbitrary, and all running at the same rate – an inconceivability within the ambit of Einstein's theories – which consider complete physical equivalence of inertial systems to be achieved only in the *absence* of any tampering with the natural running rates of clocks.

5. A Passing Remark on "Now"

On a constructive note, the GPS methodology permits operational definition of a form of universal or "collective" time whereby a "now" exists everywhere, together with past, future, and distant simultaneity. This superficially resembles the "frame

time" of SRT, as noted, but the latter employs co-moving uncompensated clocks, all at rest in the given inertial frame, whereas here compensated clocks move arbitrarily without regard to frame (and could include all clocks in the universe in all states of motion). Thus they and the collective time they tell are not limited to any preferred state of motion (although for the rate consistency demanded by any form of RP the specific compensation operations employed must vary with the arbitrarily chosen *inertial* state of motion of a Master Clock). If you, the reader, cannot accept what I have just written in this paragraph, forget it. The rest of what I have to say in this paper is independent of it, and its full support requires more exposition than space allows.

6. Incompatibility of Clock Rates with the RP

The RP asserts the equivalence of all inertial systems for formulating the *laws of nature*. If, as we have suggested, naturally-running clock rates are objectively different in two inertial systems, this means that all natural physical processes proceed at different rates, and the identity of laws of nature in the two systems can be maintained only by some retreat or reformulation. It is evident that the GPS evidence confirming the objective factuality of a naturally-running clock rate asymmetry among inertial systems writes finis to the traditional form of RP as physics.

It bears reiteration that there is something special about clock rates. Being observables not delimited by specific point events, they do not lend themselves to direct description by an event calculus. SRT therefore has no logically consistent way of predicting them. In fact, as we have seen, SRT says explicitly that the clocks of two relatively-moving inertial observers run slower than each other. It mitigates this logical contradiction not a bit to say that reversing the motion of one of the observers and applying the event calculus resolves the "twin" problem. This does not resolve, it evades. If no turn-around event occurs the contradiction persists indefinitely. There is no logical compulsion for such an event to occur. Logic cannot compel events – politics can. The turn-around salvation need not happen during the tenure of any physics professor, living or dead. And, if it does, the observed asymmetrical aging outcome merely shows that at no epoch dur-

ing the entire journey could the space traveler employ SRT to predict factually the instantaneous running rate of the stay-at-home's clock. Instead, SRT makes a definite prediction of the rate of that clock different from its factual rate – which is far worse than defaulting. Thus not one of these savants can offer his students a logical resolution of the clock (or "twin") paradox based on adducible evidence even of the conceptual sort. Instead, they employ smoke and mirrors (playing up SRT's correct event-based predictions of elapsed times to distract attention from its false predictions of clock rates), supplemented by ridicule of critics such as Dingle (who was publicly accused of "dementia"). Ridicule is politics … they have nothing better to offer.

To drive another nail in this coffin, the RP is alternatively viewed as asserting a symmetry of *operational procedures* between any two inertial systems, such that similar operations produce similar results. Thus the (notional) orbiting observer and the earth-surface observer should be able to do similar clock compensation operations and get similar results. Let us look into this. Suppose the orbiting observer mimics the other and builds a dual-purpose cesium clock in orbit, set to read both proper time and (rate-speeded) compensated time. For purposes of discussion we may specify certain clock rates:

A = rate, when transported from orbit to earth's surface, of a clock built in orbit and compensated there by increasing its rate by a factor of γ.

B = rate, when not transported, of an uncompensated clock built in orbit and showing natural or proper time there.

C = rate, when not transported, of a clock built on earth's surface and compensated there by increasing its rate by a factor of γ.

D = rate, when transported from earth's surface to orbit, of a clock built on earth's surface and compensated there by increasing its rate by a factor of γ.

E = rate, when not transported, of an uncompensated clock built on earth's surface showing natural or proper time there.

If symmetry prevailed, the orbiting compensated clock, when retro-fired in a rocket and returned to earth's surface (clock A), should run in step with the orbiting proper-time clock B, A = B. [That is, by the RP, the symmetry D = E demands a matching symmetry A = B.] But in fact clock A must run in step with the permanently-resident earth-surface compensated clock C, A = C, because the compensation operation (substitution of N_0' for N_0) was numerically identical in both inertial systems, and all clocks sharing a given state of motion run at the same rate when set in the same way. [Thus any naturally-running clock, wherever built and however orbited, when returned to earth's surface via any history of motion, without fiddling its rate, will run *after return to earth* at the same rate as native proper-time clocks permanently resident there. All theories agree on this. For example, Einstein founded his SRT on an implicit "state function" assumption – one of several unstated assumptions – that natural clock rates are a function of their state of motion. This means that all uncompensated clocks, regardless of history, when placed in a given state of motion, run at the same (natural or proper time) rate, other things such as gravity being equal. This state function attribute must apply also to all clocks set to run in the same way – *e.g.*, compensated by a given γ-factor.]

Since the compensated-in-orbit-and-transported-to-earth clock A runs in step with the earth-surface compensated clock C, A = C, it cannot run in step with the orbiting proper-time clock B (as demanded by relativistic symmetry), because the latter by its setting runs slower than the orbiting compensated clock D, B < D. The clock D is known from GPS data to run at the same rate as the earth-surface proper-time clock, E, E = D, which in turn by its setting runs slower than the earth-surface compensated clock, E < C. Thus our inequalities yield B < D = E < C = A, or B < A, which contradicts the symmetry requirement B = A of the RP. In short, operational symmetry fails, and with it the RP. Incidentally, this argument shows that $B < E$, hence $B \neq E$, so proper-time symmetry fails, as we have repeatedly claimed.

Note that the inequalities involved in this argument are between what I assert to be directly observable quantities, clock rates. SRT by its basic terms of reference demands that all observ-

able aspects of the physical world be expressible in terms of point events and describable by an event calculus (the "Lorentz transformation"). Clock rates, being of an essentially rootless character, free of epoch and duration, do not fit this requirement. SRT's answer to all such problems is to *force* them into the event mold. Once this has been accomplished, all contradictions and paradoxes disappear (because phase effects correct rate anomalies). For example, an acceleration-free version of the twin paradox calls for uniformly moving inertial observers, when passing one another, both going and coming, to set their clocks to equal numerical values at the point events of closest passage. This enables SRT's event calculus to predict correctly the different elapsed times … while leaving quietly unresolved (but claimed to be resolved by a phase jump) the dilemma of discordant clock rate predictions.

Thus the issue of a manifestly wrong (contradictory) prediction of rate is evaded by adducing a right prediction of elapsed times. The logic is that telling the truth about Peter absolves lying about Paul … or that giving a true answer to Question A excuses a false answer to Question B. This would not get by in a court of law, however corrupt such a court might be. That it has succeeded among physicists for 100 years tells you something about physicists you did not want to know. Clock rates are manifestly physical "observables" in their own right, entirely apart from and logically independent of clock phases or elapsed times. The fact that SRT tells the truth about elapsed times (via its event calculus) does not license it to tell logically contradictory fairy tales about rates. The point about the GPS data is that they bring clock rate information to the forefront of the mind and make it difficult to evade recognition that *rates per se* do not fit an event calculus. Difficult, but not impossible. Never that!

7. A Crucial Experiment

Are there any experimental questions that need to be answered in this connection? Consider the dual-purpose clock previously described, which represents either an uncompensated proper-time clock C or a compensated clock C*, depending on which of its two internal counters is consulted. We know that when located on the earth's surface the C-clock measures light

speed as *c* and the C*-clock measures it as not-*c* (*i.e.*, as c/γ). What is the situation when this same dual-purpose clock is transported into orbit? SRT tells us in no uncertain terms that also in that case the C-clock measures light speed as *c*, so the C*-clock must again measure it as c/γ. But SRT depends for its reasonings on the RP, which we have just seen to be under a dark shadow of doubt. Moreover, since the C*-clock on earth measures speed c/γ and is factually slowed by a γ-factor when placed in orbit, it should measure speed *c* there, absent the Lorentz contraction (causing a change of measuring apparatus dimensions). A test of the matter might therefore be conceived as an implicit test of the Lorentz contraction. We have suggested an "equivalence" of compensated clocks in orbit and (dropped, momentarily free-falling) proper-time clocks on earth. (The latter assuredly measure *c*.) It may be that this equivalence extends to the equivalence of light-speed measurements, indifferently to whether the *inertial measuring apparatus* is located on earth or in orbit. In that case the C*-clock in orbit would have to measure *c*. So, the question is open and in need of empirical probing. (Recall that this discussion is premised on all effects of *location* in a gravity field being separately compensated.)

8. What About the Lorentz Contraction?

SRT exists apart from nature in its own sphere of self-supporting story-telling. It is an event calculus that can never be refuted by logic nor shown to be self-inconsistent. The question about it from start to finish has always been, is it physics? Its supporters believe (fanatically) that this is the case, to the point that many transubstantiate it from theory to fact. But we have just seen that one of its basic logical ingredients, the RP, is physically questionable, at least as usually interpreted in respect to symmetry among inertial systems of naturally-running clock rates. We may be sure that SRT, correctly applied as an event calculus, will give a coherent and self-consistent accounting of the GPS situation. I have not personally verified this, but assume it to be true on the basis of many similar cases and calculations. But it will do this not only by fiddling phases but by contorting space (Lorentz contrac-

tion of the orbiting light-speed measuring apparatus). The latter is an aspect of the theory that has never been verified and is subject to the gravest suspicions.

The whole half of SRT that asserts the invariance of a "proper space" interval $d\sigma = icd\tau$, based on hypothesizing the reality of a link between different particle worldlines where no light signal can reach, is entirely without observational or even plausibility support – it being implausible mysticism to assert that a quantity by definition operationally indefinable should be physically invariant (real). No experimental measurement of the Lorentz contraction has ever succeeded, though several determined attempts have been made. Thus all "world structural" statements of SRT are devoid of empirical support. To question such metric statements is to question the theoretical basis for the Lorentz contraction (its only basis). The empirical evidence supporting SRT (and there is a vast amount of it) is exclusively evidence for a special kind of proper time $d\tau$ invariance, *viz.*, $d\tau$ in all cases is defined in terms of delimiting event points *on single-particle worldlines*, never on different-particle worldlines. The failure of the RP in respect to clock rate description does not imply its failure in respect to elapsed time (point event) description for that limited class of events.

The objective reality of time dilatation, indicated by the GPS evidence, demands a matching objective reality of the Lorentz contraction, *if any* … so the persistent failure of experiment to back up the latter reality is doubly a cause for concern. To test the issue in a simple manner, it would be desirable to construct a dual-purpose clock, as defined above, put it into orbit, and use it in a suitable apparatus to measure light speed with each of the two clocks. One clock will measure *c*, the other not-*c*. Which? SRT says that the naturally-running C-clock will measure *c*. This may well be confirmed. But, considering the rate-descriptive failure of the RP, the case is not open-and-shut. Such circumstances of uncertainty are precisely those in which an experiment should be done. Ratiocination and debate can take us only so far. In view of the light that would be cast on the Lorentz contraction, there is more to be learned by doing the experiment than by speculating about it.

In what sense would the proposed experiment be crucial? If the orbiting uncompensated C-clock measured *c*, this would be seen as confirming the objective physical Lorentz contraction of the measuring apparatus in orbit and validating the prediction of SRT. If the compensated C*-clock measured *c*, this would indicate invariance of length and invalidity of the metric statements of SRT. The particular interest of such an outcome would be its demonstration of a conclusive violation of Einstein's second postulate of light-speed constancy (since the C-clock would measure not-*c*) – whereas here I have questioned only his first postulate (the RP). Had I a reputation I would stake it on the unexpected outcome. Luckily, circumstances preclude that risk.

9. Prospectus

The GPS shows time dilatation to be a real physical phenomenon. But this over-fulfils the quota: SRT does not want it to be too real, because it wants it to be symmetrical between inertial systems … and symmetrical asymmetry is logically incompatible with reality. Considering the GPS evidence, I can see no refuge for the RP, interpreted in the traditional way as a symmetry principle indiscriminately governing the *rates* of naturally-running clocks. It is finished, kaput. It is broken, and, if you are smart enough to know a way, now is the time to step forward and fix it.

There is little doubt that some form of the RP must hold. The question, I venture to suggest, is how to conceptualize "time" in order to make it hold. Einstein conceived of time as what naturally-running clocks tell, thus as affected by gravity and by motion. I propose instead that time (like temperature and other simplest physical descriptors) be defined in such a way as to make it independent of irrelevant environmental influences. Time, in other words, is merely *suggested* by clocks. Clocks are subservient to time, not vice versa. GPS evidence indicates that Einstein's version of the RP fails; whereas I believe it can be shown that for the other (more idealized or Platonic) conception of time a valid RP can be formulated – although no proof of this proposition has been attempted here.

Regardless of such speculations, the vast teeming masses of academic physicists and others who believe implicitly in Ein-

stein's form of the RP deserve to be shaken up by a closer acquaintance with the facts. It is time for their Great God Consensus to experience another of His historic belly aches leading to a "paradigm shift." The experiment I have suggested might get that evolution started.

Finally, let me say that any setback for the RP will be instantly seized upon by supporters of "the" supposed alternative theory to SRT, the Lorentz ether theory (whereby a physical ether is assigned a determinate state of motion). I do not myself accept this as the only, or even an attractive, alternative … far from it. It is a challenge to human imagination to find satisfactory options, to be sure, but I feel reasonably confident this challenge can be met. It is merely necessary to discard discredited past truths and start again with a *tabula rasa*. Old men, and those of established reputation, find that difficult; but any child can do it with ease.

2006 should be a good year to get started on the project … now that the celebrations and the hoopla have died down, any real physicists rattling around at loose ends – not tied down mentally by their fealty to political correctness and obligations to academic tenure – can throw off the shackles of 1905-2005 and have at the problem afresh. They have nothing to fear but fear. SRT is a paper tiger, a stuffed Hobbes. Everybody, beginning with Dirac, has been dutifully saying all along that quantum mechanics (with its hard-to-evade message that distant simultaneity is operationally definable, hence not "relative") has to be modified in deference to this fearsome tiger. Maybe it's the other way around …

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