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Anomalies in Relativistic Rotation

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Abstract—Under scrutiny, the traditional analysis of relativistically rotating objects appears internally inconsistent and in disagreement with actual and thought experiments. By applying fundamental relativistic/geometric principles to rotation, one finds that time on rotating objects may not be orthogonal to space, and that such non-time-orthogonality appears to resolve all known inconsistencies and disagreements with experiment. Ramifications of non-time-orthogonal geometry have not previously been explored, and are not part of the traditional analysis. The non-time-orthogonal analysis approach does not contravene traditional relativistic theory for translating systems (for which time is orthogonal to space) and makes many (but not all) of the same predictions for rotating systems as does the traditional analysis. Non-time-orthogonal analysis is posited herein as the most general embodiment of relativity theory, which reduces to the traditional theory when time is orthogonal to space. Of particular relevance, rather dramatic predictions of non-time-orthogonality appear to have been verified in little-known experimental results of Brillet and Hall and the global positioning satellite system. The presentation is simplified for the benefit of non-physicist readers.

Keywords: relativistic—rotation—non-time-orthogonality—Michelson-Morley—Brillet and Hall

"There is much misinformation presently circulating among those who refuse to look at the evidence themselves, and the history of science is full of cases of refusal to face and deal with anomalies—and of major advances in knowledge when the anomaly is finally acknowledged and confronted."

Robert L. Hall[1]

"... a single experiment can prove me wrong."

Albert Einstein

Like other members of the SSE, I have known the exhilaration of paradigm-challenging, anomaly-resolving insight as well as the ensuing deflation in trying to get such insight published. Having read in this journal other accounts of such experiences, I had resisted adding my own story to those already told.

However, following a series of recent mainstream journal *ad hominem* rejections (see Appendix) from referees who displayed little understanding of my manuscripts and failed to prove anything therein wrong, I began to reconsider[2–4]. The "clincher" was the realization that many readers of the JSE are physicists, themselves sympathetic to maverick perspectives, who might become allies of a sort in one's struggle with the established order. At the least, they would represent a body of scientists who could recall one's position, should future experiments or theoretical shifts bring it into favor.

This article presents one such position in a manner that should make it intelligible to most readers of this journal.

Relativity: Translation and Rotation

An object is considered to be moving relativistically if its speed approaches that of light. Relativistic rotation, in turn, implies that at least parts of an object furthest from its axis of rotation move about that axis at comparable speeds. Motion at such speeds, as those with even a casual knowledge of relativity theory know, implies a number of seemingly strange phenomena. Time on the object slows down, mass increases, and meter sticks aligned in the direction of the velocity presumably contract.

These results arise from a theory (relativity theory) having two fundamental postulates. The first of these, a paradigm-shattering cognition by Einstein, is that the speed of light c (approximately 300,000 km/sec) is measured the same by all observers[5]. This is true regardless of their individual conditions, i.e, their particular states of motion, the forces they experience, etc.

A manifestation of the second[6] postulate is that velocity is relative. An object may move with respect to us at a particular velocity, but an observer fixed to the object considers it to be stationary. More profoundly, there is no experiment any observer could perform that could determine her "true" velocity. That is, there is no such thing as true (i.e., absolute or inherent) velocity.

Using these two postulates, one can then derive the special theory of relativity. From it, the well-known predictions such as time dilation, length contraction, and mass-energy dependence on speed fall out directly. So these effects depend ultimately on the two postulates. If they were different, the effects would be different.

It is important to understand that

1. These speed-dependent effects are also an integral part of the more widely ranging theory of general relativity (of which special relativity is a subset).
2. The effects are reciprocal. Consider two observers in motion with respect to one another. Each observer sees her own speed as zero with her own time, mass, and length as normal and unchanged. But each also sees the speed of the other as non-zero with concomitant time dilation, mass-energy increase, and length contraction seeming to occur to the other observer.
3. The special theory is derived for translation[7] (motion in a straight line), and hence these effects are first and foremost for translating systems.
4. Time dilation and mass-energy dependence on speed have been verified *directly* in many tests. Many of these tests involve rotation (e.g., cyclotron experiments), and so it was generally accepted, without extensive reflection, that the principles (the postulates, the mathematics, the predictions) of special relativity apply not only to translation, but also to

rotation. For instance, the velocity of an object on the rim of a rapidly rotating disk would presumably give rise to the same phenomena, and be governed by the same equations, as an object moving with the same speed in a straight line[8].

5. It is impossible with present technology to measure length contraction directly in objects (of subatomic size in typical experiments) traveling at close to the speed of light. The length contraction effect has, however, been verified *indirectly* by the Michelson-Morley experiment and subsequent similar experiments.
6. There are really only two types of motion, translation and rotation. Any more general motion, such as that one experiences while turning corners and/or riding on a highway in a car, are merely various (and often changing) combinations of these two types. A complete theory of motion must encompass, and make correct predictions for, both.

In my experience, most physicists routinely assume that relativistic rotation was all but accounted for in Einstein's seminal delineation of the general theory of relativity in 1916. It is taken for granted that any details most certainly were worked out during the ensuing few years of intense theoretical research on the theory. Throughout the decades since, however, journal articles[9] have repeatedly appeared here and there noting certain conundrums, seemingly intractable inconsistencies, associated with merely applying the extant theory directly to rotation. These have, for the most part, been ignored by the mainstream physics community. I summarize several of these, provide references to others, and present some of my own insights in this regard below.

Rotation and the Relativity Postulates

"Physics is like a hard boiled egg. It is irreversible. Once it's cooked, it can't be uncooked."

Franco Selleri[10], physicist, iconoclast

The traditional approach to relativistic rotation can be illustrated by considering a rapidly spinning disk. An object or observer fixed to the disk rim has a velocity tangent to that rim, and his velocity (from our perspective on the ground) is continually changing direction as the disk rotates. For a very short period of time, the thinking goes, one can consider the disk-based observer/object to have rectilinear (continuing in the same direction along the same straight line) velocity, and use all the usual mathematical tools of relativity theory. One then predicts time dilation, mass-energy dependence on speed, length contraction, and other things in accord with the relativistic theory for translation. As mentioned above, the first two of these have been confirmed directly via experiment.

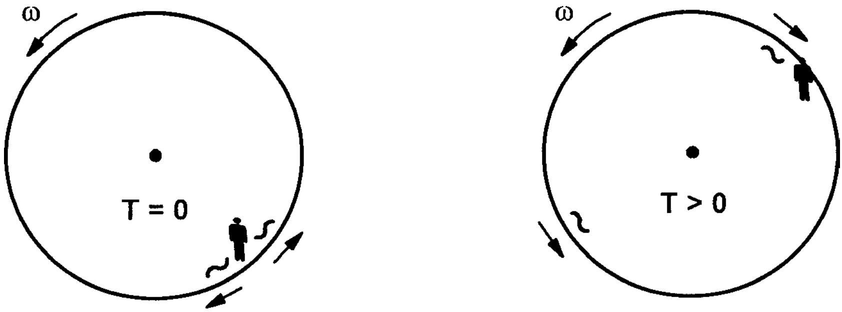

Fig. 1. Rotating disk observer measuring light speed.

The First Postulate: Invariant Light Speed

Recall that the speed of light, according to the first relativity postulate, must be measured the same by any observer, under any conditions. Note that we can measure speed by laying down meter sticks over a given distance and using a clock to measure the time taken to travel that distance. Keeping the first postulate in mind, consider the following thought experiment involving an observer fixed to the rotating disk of Figure 1 who measures the speed of light.

In Figure 1, the Greek symbol ω represents the rotational speed (revolutions per second) and the arrow juxtaposed to it, the direction of rotation. The observer shown has already laid meter sticks along the rim circumference and determined the distance around that circumference. As part of his experiment, he has also set up a cylindrical mirror, reflecting side facing inward, all around the circumference. He takes a clock with him and anchors himself to one spot on the disk rim. When his clock reads time $T = 0$ (left side of Figure 1), he shines two short pulses of light (the mini sine waves in the figure with accompanying arrows indicating direction) tangent to the rim in opposite directions. The mirror will cause these light pulses to travel circular paths around the rim, one clockwise (cw) and one counterclockwise (ccw).

From the ground we see the cw and ccw light pulses having the same speed, c, the usual value for the speed of light. Note, however, that as the pulses travel around the rim, the rim and the observer fixed to it move as well. Hence, a short time later, as illustrated in the right side of Figure 1, the cw light pulse has returned to the observer, whereas the ccw pulse has yet to do so. A little later (not shown) the ccw pulse will have caught up to the observer.

For the observer, from his perspective on the disk, both light rays travel the same distance, the same number of meters around the circumference. But his experience and his clock readings tell him that the cw pulse took less time to travel the same distance around the circumference than the ccw pulse.

What can he conclude? He can only conclude that, from his point of view, the cw pulse traveled faster than the ccw pulse. Hence, the speed of light as measured on the rotating disk does not always have the same value. It is different in different directions, and different from that measured on the ground.

Bottom line: the first postulate of relativity theory does not seem to hold for rotating systems[11].

This thought experiment, to my knowledge, has never appeared in a mainstream journal, let alone been considered openly by the physics body politic. I have tried to publish this in a major journal, but have been denied for "reasons" having nothing whatever to do with the underlying logic of the problem. In response to one particularly strident referee, I asked that he or she either kindly show me where in the literature this issue is resolved or provide a resolution of his or her own. The reviewer ignored this request and simply reiterated, even more fervently and pejoratively, that the manuscript be rejected.

"By academic freedom I understand the right to search for truth and to publish and teach what one holds to be true. ... It is evident that any restriction on academic freedom acts in such a way as to hamper the dissemination of knowledge ..."

Albert Einstein

The Second Postulate: Velocity is Relative

Without looking outside, an observer on the rim of a rotating disk can determine his rotational speed. Using, for example, a simple pendulum, he can note how the arc-like path traced out by the pendulum's bob rotates 360° (one revolution) every so many seconds, and hence calculate the value for ω (revolutions per second) at which he is rotating.

He can also determine the center of rotation using a force-detecting device like a weighing scale. Setting up the scale in two different locations and noting the line of action of the force (the direction the scale is pulled due to centrifugal "force"), he can see where these lines of action cross. That spot is the center of rotation and he can measure his distance from the rim, call it r, to that center.

With this information, and a modest knowledge of physics, he can easily calculate precisely what the rim velocity is in meters per second about the center[12]. That is, contrary to the dictate of the second postulate, there are experiments he can perform that determine his absolute velocity. His velocity is not relative. It has an absolute quality to it.

Bottom line: The second relativity postulate does not seem to hold for rotating systems.

I have not seen this point made anywhere in the literature, though again, I have been trying unsuccessfully to raise awareness of it.

Conclusion: Rotation and the Relativity Postulates

"Science becomes dangerous only when it imagines that it has reached its goal."

George Bernard Shaw

If a theory is derived from certain postulates and these postulates do not hold for a particular case in the real world, then how can we expect every prediction of the theory to match what one measures for that particular case? We can't, and we shouldn't, but the prevailing paradigm for relativistic rotation does.

Length Contraction and Rotation

"The important thing is not to stop questioning."

Albert Einstein

As mentioned, the predicted effects of time dilation and mass-energy dependence on speed are, in fact, observed directly in the essentially rotating systems of cyclotrons. Length contraction, on the other hand, cannot be observed directly. But we can examine its consistency for rotating frames with another thought experiment.

The traditional analysis of rotating frames assumes that lengths on the rotating disk contract circumferentially. The greater the distance r from the center of rotation, the higher the tangential speed, and hence the greater the contraction. The traditional analysis then concludes that the disk surface, if flat when stationary, must be curved when rotating. As the disk speeds up, the outer regions contract more than the inner regions, resulting in a curved disk surface[13].

Recall, however, that the disk observer, according to the theory, does not observe his own lengths contracting[14]. Only another observer moving relative to him sees his length dimension contracted. Hence, from the point of view of the disk observer, there can be no curvature of the rotating disk surface, and the analysis is inconsistent.

Furthermore, the disk observer looks out at the meter sticks at rest in the lab close to the disk's rim and sees them as having a velocity with respect to him. Hence, by the traditional logic, he sees them as contracted in the circumferential direction. He must therefore conclude that the lab surface is curved. But those of us living in the lab know this is simply not true, and again the analysis is inconsistent.

Bottom line: Length contraction applied via the traditional analysis to rotating systems is self-contradictory.

Relativistic Rotation Experiments

Sagnac's Experiment

In 1913 G. Sagnac[15] carried out an experiment similar in many ways to the thought experiment of Figure 1. On a rotating platform he split light from a single source into cw and ccw rays that traveled identical paths in opposite directions around the platform. Because measuring arrival and departure times of light with the precision required for our thought experiment is not possible, Sagnac did not measure such times, but did something essentially equivalent. He combined the returning rays such that their wave forms interfered with one another to form a visible interference pattern of alternating light and dark fringes. If the speed of light were invariant and always equal to *c*, then the speeding up or slowing down of the rotation rate of the platform would not change the location of the fringes. However, he found that the fringes did indeed shift as the speed of rotation changed. A number of others[16,17] subsequently performed the same test with the same results. Furthermore, quantitative analysis of Sagnac's results[18,19] matches what one would find by using the rotation-rate-dependent, non-invariant light speed on the disk of our earlier thought experiment.

Despite this, the predilection for invariant light speed on the rotating frame remains entrenched to this day. Attempts to resolve this conundrum by those few "mainstreamers" who even choose to recognize it seem much like the proverbial square peg in the round hole[20,21]. Of vital importance, however, all such analyses known to me fail the crucial test of correctly predicting arrival and departure times of the cw and ccw light rays as delineated in the thought experiment of Figure 1[22].

As an aside, note that we once again have a case where velocity can be determined absolutely by tests internal to a given frame of reference, in stark contradistinction to a fundamental relativity postulate. This time the test is the Sagnac experiment.

A Modern Michelson-Morley Experiment

The famous Michelson-Morley experiment formed the original experimental foundation of relativity theory. We do not detail this experiment here, but refer interested lay readers to Born[23]. We note in summary that the test was made in the pre-relativity 1880s and intended to measure the earth's *absolute* speed through the universe. This, it was reasoned at the time, would probably be close to its speed in orbit around the sun. (We have since discovered galaxies and now know that the speed of the solar system around the galactic center is actually significantly higher than the solar orbit speed.) Turning the experimental apparatus in different directions should, due to the earth's presumed absolute speed, result in different signals for different directions. This absolute speed would be directly related to the difference in signals for the different directions.

Remarkably, Michelson and Morley found no such difference, no matter what direction the apparatus was turned. Twenty years later, Einstein explained this null result in his special theory of relativity, and it has been verified in a number of subsequent tests. Thus, it was concluded, there is no such thing as absolute velocity.

In 1978, however, Brillet and Hall[24] unwittingly threw a monkey wrench into the mix. They carried out an experiment similar to that of Michelson and Morley using lasers, and obtained exceptional accuracy. Their accuracy was in fact sufficient enough to detect an effect, not just from the large solar and galactic orbital speeds, but also from the much smaller surface speed of the earth rotating around its axis. To this day, this is the only Michelson-Morley type test ever performed that could detect any effect from the earth surface speed.

Brillet and Hall found null signals for the solar and galactic orbit speeds. However, they noted, and appeared not to recognize the significance of, a persistent non-null signal at 2×10^{-13}, which they simply deemed as "spurious" with no further explanation.

Shortly thereafter, an analysis by Aspden[25] indicated that this signal corresponded within a few percentage points to what the pre-relativity physicists of 1880 would have predicted from the earth surface speed at the location of the test. Aspden's work was largely ignored[26].

"Experimental confirmation of a prediction is merely a measurement. An experiment disproving a prediction is a discovery."

Enrico Fermi

Gravitational Orbit vs True Rotation

Why should we get a null signal for the solar and galactic orbital velocities, but a non-null signal for the earth surface speed from its own rotation?

In my analysis[27], described in greatly simplified form below, I note that a body in gravitational orbit (such as that of the earth around the sun or the solar system around the galactic center) is in free fall. Thus, it feels no force, provided it does not rotate about its own axis. In such cases, there is no experimental means by which one could measure (without looking outside at the stars) one's rate of revolution in orbit. A pendulum's arc does not move over time, so you cannot determine any rate of rotation about the sun (or galactic center.) You feel no force, so you cannot use a scale to determine where the center of rotation is. Hence, you cannot determine any absolute speed, and the second postulate of relativity holds. Related logic[28] leads to the conclusion that the speed of light on such a body is invariant and equal to c as well.

Thus, the usual form of relativity should hold for gravitational orbits and we should expect a null Michelson-Morley result for orbital speeds, which is just what we measure. However, one *can* use a pendulum and scales to determine the speed of the earth's surface about its axis, and therefore we should expect that relativity theory will not hold in precisely the same form for that case. The Brillet and Hall result justifies that expectation, though it has yet to be generally realized.

Once again we have an experiment, this time that of Brillet and Hall, in which we can measure velocity absolutely from entirely within a rotating system.

The Satellite Global Positioning System

The Global Positioning System (GPS) utilizes electromagnetic (light, effectively) signals sent back and forth between satellites in orbit and equipment on the rotating surface of the earth. As a result of studies on the associated data, recognized world leading GPS expert Neil Ashby recently noted in *Physics Today*:

"... the principle of the constancy of c [the speed of light] cannot be applied in a rotating reference frame ..."[29].

He has also stated:

"Now consider a process in which observers in the rotating frame attempt to use Einstein synchronization [constancy of the speed of light].... Simple minded use of Einstein synchronization in the rotating frame ... thus leads to a significant error"[30].

I submit that the experimental verdict is in. It just has yet to be recognized.

Non-Time-Orthogonality in the Theory of Relativity

Relativity theory is actually, and most fundamentally, a theory of geometry. In the purest sense, the standard postulates of both special and general relativity can be considered but ramifications of a deeper natural mathematical order. Within that natural order exist three dimensions of space (typically expressed as x, y, and z axes) and one dimension of time (a t axis). We can visualize the three spatial axes as mutually perpendicular. Each is orthogonal to the other two. We have trouble visualizing a fourth dimension (time) as then perpendicular to each of the other three, because we are essentially three-dimensional beings, limited to three-dimensional worldviews. In the mathematics of relativity theory, however, time is generally expressed as a fourth axis, orthogonal to the other three. Using just one spatial axis, it is easier to see the relationship between space and time, and we do that in Figure 2. In the left side of Figure 2 the horizontal x axis represents space and the vertical t axis, time. Actually, it is convenient to plot time multiplied by the usual speed of light c (300,000 km/sec) on the vertical axis, but that only affects proportion in our graph. The underlying essence is unchanged.

The 45° line in the left-hand side of Figure 2 represents the path of a ray of light in space and time. If time $t = 1$ second, then light must travel 300,000 km in that time, so $x = 300{,}000$ km. When x has this value, ct will also equal 300,000, and hence light in spacetime can be seen to travel a 45° path.

Consider that the light path in Figure 2 is always the same regardless of what observer happens to be seeing it. In translating systems, time is orthogonal to space, as shown in the left side of Figure 2, and that 45° angle path of light always results in $x = ct$. The speed of light is the distance it travels (x) divided by the time it takes to travel (t). This then is $x/t = c = 300{,}000$ km/sec.

Using rather straightforward mathematics[31], one can show that a rotating frame has time that is *not* orthogonal to space. This is illustrated in the right side of Figure 2, where the spatial (horizontal) axis points in the circumferential direction of the disk, and the time axis is not vertical. I have dubbed this "non-

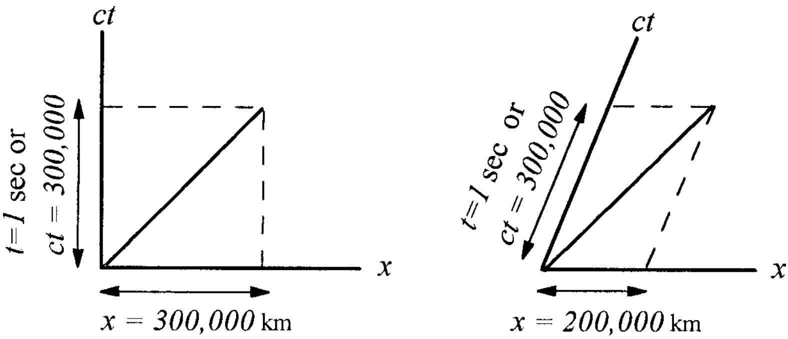

Fig. 2. The speed of light in orthogonal and non-orthogonal systems.

time-orthogonality" (NTO). It results from *true* rotation in which centrifugal forces can be felt and measured, but not from gravitational revolution in which no such forces exist.

The right side of Figure 2 represents the view of an observer on a rotating disk looking at the same ray of light as the non-rotating observer of the left side. The path of the ray of light itself is unchanged and is still 45° relative to each of the original space and time axes of the left side. On the right side, however, and hence for the observer in the rotating frame, the same ray of light is no longer 45° from the time axis. To calculate the speed of light in this case, we need once again to find x/t for the light path line. But here, x is only 66.7% (in this example) of what it was on the left side of Figure 2, yet t is the same[32] as it was on the left side. Hence, the speed of light in the circumferential direction is 66.7% of what it was on the left side, i.e., 200,000 km/sec.

Thus, we see that in NTO systems, the speed of light can be other than c, and this result is due solely to the fact that time and space are not orthogonal in such systems. Quantitatively, the mathematics of NTO analysis leads to predictions for the speed of light in the rotating earth frame that would result in a signal like that measured by Brillet and Hall and data like that found in the GPS. It also leads to time dilation and mass-energy dependence on speed that turn out to be exactly the same as that found for translation. Furthermore, it predicts no length contraction effect[33], thereby resolving the aforementioned inconsistencies of the traditional analysis.

Bottom line: NTO systems have non-invariant speeds of light. Well-accepted mathematics applied to rotating frames shows such frames to be NTO. The geometrical foundation of relativity theory remains unaltered, but the ramifications for rotation are different than that for translation. No self-contradictions arise in NTO theory, and all experimental results are predicted.

Yet resistance to publication of this analysis approach, and its concomitant prediction of a non-null Michelson-Morley result, is extreme.

"Freedom to differ is not limited to things that do not matter much. That would be a mere shadow of freedom. The test of its substance is the right to differ as to things that touch the heart of the existing order."

Former U.S. Supreme Court Justice Robert Jackson
on freedom of speech, akin to academic
freedom of speech/publication

"Fermi's revolutionary idea [of the neutrino] was not accepted for publication in the major publication *Nature* and was printed instead in a relatively obscure Italian journal."

Fraser, Lillestøl, and Sellevåg[34]

Other Issues

There are other issues I will not attempt to explain here, but instead refer interested physicists to articles cited in the references. I do mention one in passing.

The traditional analysis of relativistic rotation predicts a discontinuity in time on a rotating disk. That is, the end of a measuring tape fitting once around the circumference of the disk does not, according to that analysis, meet back up with its other end at the same point in time. Stated another way, a bit more technically, time on the disk is multi-valued and path dependent. The traditional theory predicts that an event will have different times on the same clock located at that event depending on the route one takes to reach that event. Stated yet another way, a clock is out of synchronization with itself.

This bizarre prediction has to my knowledge been recognized and addressed in the mainstream literature only once[35]. That author claimed to resolve the issue by stating that physics can be done locally (over a small region) on an open path on the disk, but that closed paths on the disk are not allowed. This then implies that nature would somehow prevent me from walking completely around the circumference of a merry-go-round. Or from painting a continuous line all around its rim.

NTO analysis makes none of these physically unacceptable predictions about time. Time therein is continuous and single valued. All clocks are in synchronization with themselves and the ends of a circular measuring tape do indeed meet back up with each other at the same point in time.

Summary

The traditional analysis of relativistic rotation is inconsistent with regard to i) its own postulates, ii) its predictions for length contraction, iii) the global positioning system satellite data, iv) the Brillet and Hall experiment, v) the Sagnac experiment, and vi) the continuous and single-valued nature of physical time. NTO analysis, on the other hand, is both internally consistent and in agreement with all known experiments. Furthermore, NTO analysis does not contravene the extant relativistic theory for translating systems (for which time is orthogonal to space), which comprise the vast majority of cases treated in special and general relativity. NTO analysis is posited to be the most general embodiment of relativity theory and reduces to the traditional theory when time is orthogonal to space.

Addendum

If I have seemed a bit imperious in championing my own analysis and denigrating the prevailing one, then I beg the reader's forgiveness and indulgence. I was trying to make a point, and realize that I may be right or I may well be wrong. If one day proven wrong, I hope I will be able to accept that gracefully. If proven right, I hope I will be able to accept that humbly. Regardless, I do contend, and I do so with great vigor, that I and others like me deserve to have our insights published and open to the degree of scrutiny and debate available only in a public forum.

In any event, I am profoundly grateful to be able to publish in a journal such as this, and feel indebted to the *Society for Scientific Exploration* for the vital role it plays in the advancement of knowledge. In the latter, I am sure, I am joined by you, the reader of this journal.

"Of all the communities available to us there is not one I would want to devote myself to, except for the society of the true searchers, which has very few living members at any time."

Albert Einstein

Appendix: Anatomy of a Rejection

Peer review at one of the most prestigious physics societies comprises an initial review by a single anonymous referee and a subsequent two-step appeal process for manuscripts that are initially rejected. The first step in the appeal is further scientific review by a second, named, editor/referee. The final step is a judgment as to fairness of the prior process by the Editor-in-Chief overseeing all the society journals.

The following is my final letter of appeal and the reply by the Editor-in-Chief. I leave it to the reader to judge whether the review for fairness was any fairer than the review for scientific merit.

Dear Editor-in-Chief:

Although I sense the futility in this, I would be remiss if I did not make a final appeal on the [referenced] submission, based on the following.

First, neither the anonymous reviewer nor Professor ____ addressed the content of the submitted manuscript. Both confined their attentions to prior published articles [refs. 3 and 4]. The first reviewer justified his rejection on conjecture about that prior work. Dr. ___ incorrectly surmised that the material in the submitted manuscript has already "been thoroughly aired" in print, and based his rejection on that supposition. This is manifestly untrue, as nothing in the referenced articles even mentions the Byl et al or Dufour and Prunier experiments, upon which the present submission is centered.

Second, the rejection does not appear to be based on any of your journal's stated publication criteria. As stated in your editorial policy, you accept manuscripts that

1. significantly advance physics (new results)
2. are scientifically sound
3. are in satisfactory form (proper style, English), and
4. for new theoretical views on fundamental principles, contain convincing arguments that the new predictions and interpretations are distinguishable from existing knowledge, and do not contradict established experimental results.

With regard to 1 above, this paper presents the first and only analysis that correctly predicts the results of all three of the Byl et al, Dufour and Prunier, and Brillet and Hall experiments.

With regard to 2, no one has proven my analysis unsound. I request simply that the analysis be proven wrong (either via errors in math/logic or disagreement with experiment) or be accepted. As this is a scientific endeavor, and you clearly state that acceptance/rejection is based on sound science, then why can I not have scientific methodology applied in the review of my work?

I believe there are no issues with criterion 3.

With regard to 4, I have already noted the agreement with *all* experiments. This is in clear contradistinction to alternative analysis methodologies, which do not predict the Brillet and Hall finding. My analysis is thereby readily distinguished from prior knowledge.

I request that rejection be based on failure to meet one of your stated criteria, and not on an *ad hominem* basis.

Third, I understand that fairness of the reviewing process is the focus of this final appeal. In that regard I twice asked to be able to respond to the reviewers, and was twice refused. I submit that this is neither fair nor scientific. It is possible that the reviewers could be wrong, but it appears they will never hear counter arguments, never reflect on the issue to any greater depth, and never be given a chance to reconsider.

Inherent to the very nature of discovery is transcendence of traditional modes of thinking. This can, however, sometimes jar one's sensibilities and evoke reactions that inappropriately color the bearer of new insight as "confused". The final arbitrator in such matters, at least as applied to physics, is experiment. Objectively viewed, only my analysis survives that final arbitration. I ask you to consider that fact seriously as you make your decision.

Finally, despite what I consider to be sound arguments, I do not believe you will choose to accept this manuscript, and in that event, I ask the following. If in your lifetimes the Brillet and Hall experiment is repeated, and the same result obtained, then please remember that it was I who first predicted that result and provided the only viable analysis of it.

Sincerely,
Robert D. Klauber

Reply:
Dear Dr. Klauber:

I have reviewed the file of your paper ''Non-time-orthogonality and tests of special relativity'' which was submitted to _____. The scientific review of your paper is the responsibility of the editor of _____, which resulted in the decision to reject your paper. The Editor-in-Chief must assure that the procedures of our journals have been followed responsibly and fairly in arriving at that decision.

On considering all aspects of this file I have concluded that our procedures have in fact been appropriately followed and that your paper received a fair review. Accordingly, I must uphold the decision of the Editors.

Sincerely,

_____
Editor-in-Chief

Notes

[1] Hall, R. L. (2001). [Book review of *UFOs and abductions: Challenging the borders of knowledge* edited by D. M. Jacobs]. *Journal of Scientific Exploration, 15*(3), 396.

[2] I do note that the field of physics has lesser known journals that are open to ''outside the box'' research, and that I have published in one of these [see ref. 3]. Most noteworthy are *Foundations of Physics* and *Speculations in Science and Technology.* The latter is not restricted to the field of physics and has the former editor of the *JSE,* Bernhard Haisch, on its editorial board. I have also had a brief letter published in a mainstream journal [ref. 4], though I have had manuscripts submitted to that and another such journal rejected.

I note further that physicists can post articles on a Web site provided by the Los Alamos labs without undergoing the review process. Such postings are primarily used as a means to make articles available well before they appear in print, though I have found them useful for getting insights that might be blocked from formal publication recorded and dated. References herein prefixed with ''gr-qc'' represent the Los Alamos general relativity-quantum cosmology Web site posting number by which these articles may be accessed. See xxx.lanl.gov.

[3] Klauber, R. D. (1998). New perspectives on the relativistically rotating disk and non-time-orthogonal reference frames. *Foundations of Physics Letters, 11*(5), 405–443 (gr-qc/0103076).

[4] Klauber, R. D. (1999). Comments regarding recent articles on relativistically rotating frames. *American Journal of Physics, 67*(2), 158–159.

[5] Comment for physicists: The local, physically measured speed of light even within a non-inertial system is always *c.* The generalized coordinate speed of light is variable, but is not something one measures with standard rods and

clocks in experiment. There is one subtle caveat here, however. The first sentence of this footnote is strictly true only for coordinate frames in which time is orthogonal to space. See Klauber, R. D. Physical components, coordinate components, and the speed of light (gr-qc/0105071); Savickas, D. (2002). Relations between Newtonian mechanics, general relativity, and quantum mechanics. *American Journal of Physics, 70*, 798–807; Petkov, V. Propagation of light in non-inertial reference frames (gr-qc/9909081); Puthoff, H. Polarizable-Vacuum (PV) representation of general relativity (end of section II.C) (gr-qc/9909037); and ref. 3 (sections 4.2.5, 4.3.3, and 5.1).

[6] The second postulate states that the laws of nature are the same for all inertial (free fall) observers. That is, there is no preferred frame of reference for any observer, i.e., there is "reference frame democracy". Relativity of velocity is a corollary of this postulate. If velocity were absolute, we could define the frame with zero velocity as the preferred frame. Note also that in order to keep the present article simple, I ignore further postulates of general relativity (which relates to non-inertial systems) such as the equivalence principle.

[7] Comment for physicists: The Lorentz transformation, although it can be applied locally in non-inertial cases, is a transformation between frames in rectilinear motion.

[8] Comment for physicists: I am trying to keep the presentation simple. What is meant here is that the Lorentz frame metric can be used locally, i.e., used for a very small object for a very short time, even in non-inertial cases. I discuss in articles cited herein why this heretofore sacrosanct principle may not apply to rotation.

[9] Ref. 3 and several references cited therein are some of these. Other references may be found in other of my articles on the Los Alamos Web site.

[10] Personal communication. Selleri is a seasoned physicist at the Università di Bari in Italy and has over 200 publications to his credit. He recognizes the problem posed by the thought experiment of Figure 1, but has a different approach to its resolution. That approach effectively dismantles relativity theory as we know it, and does not predict the Brillet and Hall experimental result presented later in this article. In my opinion, however, it has a greater chance of being correct than the traditional approach. See Selleri, F. (1997). Noninvariant one-way speed of light and locally equivalent reference frames. *Foundations of Physics Letters, 10*, 73–83.

[11] Comment for physicists: Symmetry dictates that the local speed of light for each light pulse must equal its average speed. Average, not local, speed is of course what is measured here. Again, I emphasize that we are not talking about generalized coordinate value speeds (which can be anything depending on the coordinate grid selected) here. We are talking about measured, i.e., physical, speeds (which must be unique within any given frame.) See reference note 5.

[12] In classical physics, this speed is $v = \omega r$ (where one assumes proper units are used for rotational speed ω).

[13] Comment for physicists: Transforming from the 4D Riemann flat space of the lab to the 4D space of the rotating frame implies the 4D space of the rotating frame is also Riemann flat. The traditional analysis does not contradict this, but claims the 2D surface of the rotating disk is curved within the flat 4D rotating frame space.

[14] Tartaglia, A. (1999). Lengths on rotating platforms. *Foundations of Physics Letters, 12*(1), 17–28. Tartaglia and I have made the point in this paragraph independently.

[15] Sagnac, M. G. (1913). *Comptes Rendus, 157*, 708–718; ''Effet Tourbillonnaire Optique. La Circulation de l'é lumineaux dans un Interférographe Tournant'', *Journal de Physique Thèorique et Appliqèe*, Paris, Sociète française de physique, Series 5, Vol. 4, 177–195 (1914).

[16] Dufour, A., & Prunier, F. (1937). Sur l'observation du phénoméne de Sagnac avec une source éclairante non entraínée. *Academie des Sciences Comptes Rendus des Seances, 204*, 1322–1324; Dufour, A., & Prunier, F. (1942). Sur un Deplacement de Franges Enregistre sur une Plate-forme en Rotation Uniforme. *Le Journal de Physique et Le Radium*, serie VIII, T. III, No 9, 153–161.

[17] See other citations in Post, E. J. (1967). Sagnac effect. *Modern Physics, 39*, 475–493.

[18] Langevin, P. (1921). Théorie de l'experience de Sagnac. *Academie des Sciences Comptes Rendus des Seances, 173*, 831; Langevin, P. (1937). Relativité—Sur l'experience de Sagnac. *Academie des Sciences Comptes Rendus des Seances, 205*, 304–306.

[19] Refs. 3 and 16; see also Klauber, R. D. Derivation of the general case Sagnac experimental result from the rotating frame (gr-qc/0206033); Klauber, R. D. The speed of light in non-time-orthogonal reference frames and implications for the theory of relativity (gr-qc/0005121).

[20] Comment for physicists: For one, see Anandan, J. (1981). Sagnac effect in relativistic and nonrelativistic physics. *Physical Review, D 24*(2), 338–346. Anandan asserts: ''... [the Sagnac] effect depends only on the frequency of the beams ...'', and hence he ignores light arrival and departure time considerations, which are independent of frequency.

[21] Comment for physicists: For another, see Mashhoon, B., Neutze, R., Hannam, M., & Stedman, G. E. (1998). Observable frequency shifts via spin-rotation coupling. *Physics Letters A, 249*, 161–166. The authors consider the Sagnac effect to be a ''manifestation of the coupling of orbital angular momentum of a particle ... to rotation''. For a wave this perturbation in the Hamiltonian induces a ''frequency perturbation ... [which] ... recovers the Sagnac phase shift''. Again, correct arrival and departure times are not predicted by this approach.

[22] It is noteworthy that Sagnac, Dufour, and Prunier, the most accomplished experimentalists in the area of relativistic rotation, all considered the traditional approach unable to explain their results and believed the speed of light in rotating frames was not invariant. See refs. 15 and 16.

[23] Born, M. (1965). *Einstein's Theory of Relativity*. New York: Dover, 214–218.

[24] Brillet, A., & Hall, J. L. (1979). Improved laser test of the isotropy of space. *Physical Review Letters, 42*(9), 549–552.

[25] Aspden, H. (1981). Laser interferometry experiments on light speed anisotropy. *Physics Letters, 85A*(8–9), 411–414.

[26] I have recently found what I believe to be an error in Aspden's analysis, although I consider the general thrust of his argument valid. Specifically, he notes that if light speed is not invariant, then the path of the light beam in the Brillet and Hall experiment should be displaced when the earth surface speed is transverse to that light path. Without considering this transverse displacement, the Brillet and Hall signal would be predicted, by the analysis method advocated herein, to be about 3.5×10^{-13}, rather than the measured value of approximately 1.9×10^{-13}. I have completed what I consider to be the correct incorporation of the transverse effect into the analysis, and the resulting signal prediction is in remarkably close accord with that measured. See gr-qc/0210106.

[27] See refs. 3, 4, and 18 and related articles by me on the Los Alamos Web site.

[28] Klauber, R. D. Non-time-orthogonality, gravitational orbits and Thomas precession (gr-qc/0007018).

[29] Ashby, N. (2002, May). Relativity and the Global Positioning System. *Physics Today*, 41–47. See p. 44.

[30] Ashby, N. (1997). *Relativistic effects in the Global Positioning System.* Paper presented at the 15th International Conference on General Relativity and Gravitation, Pune, India, December 15–21; see pp. 5–7. Available at www.colorado.edu/engineering/GPS/Papers/RelativityinGPS.ps

[31] Comment for physicists: Although there is no unanimity among relativists on the correct transformation from the lab (uppercase symbols) to the rotating frame (lowercase), the most widely accepted transformation is $t = T$, $r = R$, $\varphi = \Phi - \omega t$, $z = Z$. (ω here is rad/sec, not rev/sec as it is used in this article.) Using this and standard differential geometry, one finds a metric for the rotating frame with off diagonal terms in φ and t, and hence a non-orthogonality between space and time. One can also use this to deduce a theory of rotating frames with no internal inconsistencies and agreement with all experiments. For details, see refs. 3 and 18.

[32] Comment to physicists: To be precise, time is the same to first order in v/c. The Sagnac and thought experiments described herein display first order effects.

[33] There is just one caveat here. Robert Krotkov of the University of Massachusetts has shown me a possible way in which light speed could be non-invariant on rotating frames, but length contraction could still exist. Unlike the traditional theory, however, this contraction would not be relative (i.e., it would not be reciprocal between frames). Both the rotating disk observer and the lab observer would agree that the disk observer's meter sticks contract relative to the lab meter sticks. If this were indeed the way

nature works, then we should see a null signal in the Brillet and Hall experiment. We do not, but then the non-null signal they obtained might truly be spurious. A repeat of the test by other researchers would tell us a great deal.

[34] Fraser, G., Lillestøl, E., & Sellevåg, I. (1995). *The Search for Infinity: Solving the Mysteries of the Universe.* Hong Kong: Reed International Books, Ltd. This is a delightful book intended to provide lay readers with a clear and entertaining overview of elementary particle theory, cosmology, and other branches of physics. It succeeds.

[35] Weber, T. A. (1997). Measurements on a rotating frame in relativity, and the Wilson and Wilson experiment. *American Journal of Physics, 65*, 946–953.