The Logic of a Newly Designed Optical Experiment May Resolve the One-Way Light Speed Issue

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A remarkably ingenious design for measuring the one-way speed of light has appeared in the physics literature. This paper provides a detailed description of each of its two slightly different configurations. Written for the scientifically literate reader, rather than just for the professional physicist, this report attempts to preserve the mathematical and logical integrity of the original account, while at the same time making its understanding accessible to a much wider audience. More advanced readers, those who previously have been following the issue closely, may prefer to skip the first two, introductory and background sections, and start instead with section three, where the details of the new proposal actually begin.

In sections four and five, the logic of the new technique is compared to the logic of special relativity. One of Einstein's own teaching examples, the 'long train thought experiment', becomes the central vehicle for confronting the two different approaches. After introducing minor changes to Einstein's original example -- for clarity, and similar to such changes in other teaching examples published elsewhere -- their incommensurability is demonstrated graphically.

A series of provisional findings appear in the conclusion, under the assumption that the new proposal is both logically consistent and otherwise well-founded. If the new design ultimately can be fashioned into a working instrument, and if it performs according to the expectations of its designers, then it is also argued that its practical use in collecting real physical data eventually should lead to a more rational and realistic picture of nature than the one currently anchored by special relativity.

1. Introduction

For almost a century, Albert Einstein's 'long train thought experiment' has been an officially sanctioned, as well as a straightforward way of introducing his special theory of relativity [1]. The purpose of this imaginary physics exercise only comes into clear focus after the student has climbed each rung in a seemingly inexorable ladder of logic and facts, a sequence which Einstein presents in a careful and compelling manner. Einstein called the hypothetical result of his experiment 'the relativity of simultaneity'.

A long train speeds along an embankment and is struck by lightning in two places. Both embankment and train are assumed to be inertial systems of motion. One bolt strikes at point A, toward the rear of the train; the other strikes at B, near the engine.

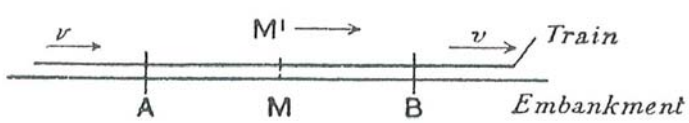

Fig. 1. Einstein's original drawing.

Observers on the embankment claim that the two distant lightning strikes occurred at exactly the same time, because in their inertial frame of reference, light from each direction reached the midpoint M on the embankment, at the same time.

But train observers see things differently. Einstein explained the physical cause of their disagreement as follows: "Just when the flashes of lightning (as judged by the embankment) occur, this point M' naturally coincides with the point M on the train, but it moves toward the right in the diagram with the velocity v of the train" [2].

Since Einstein's special theory of relativity requires a belief that light has the same consistent, one-way speed for all inertial observers, train observers can double-check the validity of their visual observation, (since puzzlingly, it differs from that of the embankment), with simple logic: that if the two light signals did not meet at the train's midpoint, then this fact, all by itself, shows that the two path lengths must have been unequal. Therefore, for them, a valid logical inference which fully agrees with their visual observation, (and their belief), is that the two strikes could not have been simultaneous; for only if the two light paths turned out to be exactly equal in length, could they have been simultaneous.

As Einstein's story concludes, both train and embankment observers agree on something. This might be thought of as the moral of his story: that special relativity theory successfully shows that if light speed really does have the same objective, one-way value for all inertial observers, then objectively, simultaneity truly must be a relative concept, and not the same for everyone, regardless of how this conflicts with one's intuition.

A standard overview, one which a well-prepared, conscientious, contemporary science teacher might provide in the classroom, while lecturing on Einstein's long train, is the following: that presently, both descriptions in the example merit the same scientific and epistemic status. At this time, neither has a better claim to objectivity than the other. Also, no physical evidence thus far has been discovered to show that any special inertial frame of 'absolute rest' exists in nature, or that any specific inertial frame of reference differs objectively from any other inertial frame. And while some have found it disturbing that reliable light-velocity measurements demonstrating this alleged univer-

sal equality of one-way light speed all have had to be derived from round-trip averages, nevertheless this seemingly less than ideal state of affairs has come to be viewed by most physicists as a limitation effectively imposed by nature -- and one which many consider permanent. One physics paper even described this situation picturesquely, as "nature's conspiracy", and as "the way nature outmaneuvers the physicist who wishes to detect anisotropy in the one-way speed of light" [3]. But this is merely a colorful conjecture and should not be taken as an objective fact.

This is because no one has ever been able to demonstrate objectively that it is not possible to measure the one-way speed of light without the use of round trip averaging. A constructive resolution of this problem, therefore, could only take place in the future if someone were to find a clever way to finesse this alleged conspiracy. Apparently such a discovery also would invalidate special relativity itself. But despite numerous attempts, and the occasional publication of a disputed claim, no method thus far proposed, officially has been recognized as being successful.

In his written statements, the redoubtable Einstein, while skillfully covering the familiar, technical, and philosophical details concerning light speed, good clocks, rigid rods, and the taking of measurements -- the underlying conceptual elements of his train experiment -- said almost nothing concerning this last negative possibility, perhaps understandably. He was being an advocate for his then obscure, new theory, and trying to present it in the best possible light. His remarks which accompanied the train example -- quoted below -- seem uncompromising and unequivocal, not at all provisional. These forceful claims -- again, quite understandably -- frequently have been interpreted as asserting some sort of objectivity; rather than merely offering up a more garden-variety, if-then, style of argument:

> "We thus arrive at the following important result: Events which are simultaneous with reference to the embankment are not simultaneous with respect to the train, and *vice versa* (relativity of simultaneity). Every reference-body (co-ordinate system) has its own particular time; unless we are told the reference-body to which the statement of time refers, there is no meaning in a statement of the time of an event" [4].

This paper concentrates specifically first upon the still open possibility described above: that there might be an undetected error in the foundation of physics; that it might turn out to be possible, indeed, to measure one-way light speed objectively. Another objective is to explain -- for those unaware of it -- and to re-emphasize, for those who are, the vastly underappreciated fact that even if there is no logical way to escape Einstein's ingenious, quasi-circular light velocity and clock setting puzzle, nevertheless, this argument, taken by itself, does not single out special relativity as the only possible way of grounding physics. The objectivity that Einstein seemed to claim in his train argument is certainly unwarranted; at least one other position can and has been constructed as a valid alternative. Mainstream physics simply has chosen not to pay much attention to this alternative. The reason for this strange and potentially dangerous group behavior is complex [5].

But if either of these two eventualities described above ever came to pass -- an objective one-way light speed measurement were to be discovered, or some other strong rationale emerged, arguing in favor of this other still possible alternate position -- even without a definitive one-way light velocity finding -- then in all probability this would cause us to look back collectively on our present situation with a certain amount of regret. Any unnecessary time wasted while trapped in a less than optimal theoretical position in physics, one worse than what might have been possible had we been more diligent or more open to alternate suggestions, shall have hindered its potential effectiveness in promoting human progress and well being. How much can only be evaluated with the necessary perspective after the fact.

But the damage could be substantial. Consequently, imprudently ignoring the risk of being trapped in such a position should be regarded as anti-rational, and if one happened to be in the position of being able to take constructive action, but did not, then one runs the future risk of being judged negligent [6].

Collectively, therefore, we should insist upon the scientific equivalent of 'fiduciary duty', taken from finance and economics. Scientific oversight must be performed conscientiously. The temporary caretakers of a healthy, collective system of scientific knowledge should welcome periodic challenges and critical questioning, rather than reflexively dismissing opposition as an annoyance. The development of alternate, foundational methodologies should be fostered by deliberate, overt, institutional support, rather than marginalized and ridiculed. Society's scientific 'bets' should be hedged with a thoroughly conservative bias, by using a checks and balances approach, rather than merely a peer review process, where all 'peers' subscribe to the same monolithic position. "Power corrupts..." is a lesson that not only can be derived from political history, but also can be illustrated by a number of disquieting episodes in the history of science.

In these worrisome economic times, with black swans and fat tails; with Bernie Madoff and the SEC's brain-dead response to Harry Markopolos; transparency and the honest accounting of foundational principles -- especially in the prestigious fields of physics and the philosophy of science -- have become all the more critical.

2. Background and History

In his most celebrated 1905 paper, the one which introduced special relativity to his fellow physicists, Einstein made this unequivocal and highly influential assertion: "We have to take into account that all our judgments in which time plays a part are always judgments of simultaneous events." [7].

Could Einstein's unreserved claim about the pre-eminent, epistemic status of distant simultaneity have been an overstatement? Could it have been merely his own, arguably subjective opinion, an opinion which in the long run might turn out to be wrong? Consider the concept of a rate of change -- by itself -- isolated from all other concepts. Does this simple notion really depend somehow upon a prior, supervening decision over how distant simultaneity must be treated? Or is the core of this important idea perfectly intelligible, without any prior consideration of distant simultaneity whatsoever? Take the RPMs (revolutions per minute) in the engines of two spatially separated automobiles, or in the engine pulling Einstein's train? In these cases, why is a systematic removal of all possible uncertainty about simultaneity, first and foremost, absolutely necessary for this

understanding? Yet certainly it is true, just as Einstein claimed, that in these examples, "time plays a part." But could this specific example possibly contradict Einstein's basic claim; might it perhaps constitute an ultimately fatal exception, a way of arguing against his entire position?

But special relativity, the theory itself, really does seem connected, almost by some sort of strange metaphysical, umbilical cord, to Einstein's seemingly blanket claim about the supreme status of distant simultaneity. Consider, however, the perplexing and dubious way in which Einstein actually explained his reasoning process:

> "But an examination of this supposition [i.e. that one-way light speeds are always the same in opposite directions] would only be possible if we already had at our disposal the means of measuring time. It would thus appear as though we were moving here in a logical circle… There is only *one* demand to be made of the definition of simultaneity, namely, that in every case it must supply us with an empirical decision as to whether or not the conception that has to be defined is fulfilled. That my definition satisfies this demand is indisputable. That light requires the same time to traverse the path from *A* to *M* [see train diagram above] as for the path *B* to *M* is in reality neither a *supposition nor a hypothesis* [Einstein's emphasis] about the physical nature of light, but a *stipulation* [Einstein's emphasis] which I can make of my own freewill in order to arrive at a definition of simultaneity" [8].

This revealing passage identifies the Gordian knot Einstein believed he was slashing. Students of physics history usually see within it echoes from the earlier work of Lorentz and Poincaré.

But frequently passed over, almost without any notice, is the fact that Einstein also felt the need for a supplement to his clear and emphatic assertion of conventionality. He called this supplement a "further physical hypothesis." Question: Was this, then, an epistemic item which was prior to and independent from the conventionality of simultaneity, or was it co-equal; or an inseparable part of the original idea? The hypothesis concerned being able to rely upon the regular behavior of *distant unsynchronized clocks*. Is this matter, then, also conventional? If so, then exactly what might be a viable alternative? Complete chaos? Or might this be a backdoor method of re-introducing and arguing in favor of a stricture similar to those earlier proposed by Kant? This issue arises again, later in the paper, with the question of just what logical entailments might be teased out of this single so-called 'hypothesis', all by itself -- i.e. without first considering the issue of how to establishing distant simultaneity. For reference, here is the exact way in which Einstein introduced his supplement:

> "This stipulation contains a further physical hypothesis, the validity of which will hardly be doubted without empirical evidence to the contrary. It has been assumed that all these clocks go *at the same rate* [Einstein's italics] if they are of identical construction." [9].

The newly discovered experimental technique to be described in this paper, parses science's dialogue with nature in an altogether different way from the way Einstein chose to do so. It relies upon a far more extended, complicated, and admittedly messy process. It does not take the risk of underestimating the difficulty of dealing satisfactorily with the very same problem which so completely captured Einstein's attention. But rather than slashing through this knot with one swift blow, as did Einstein, it requires patiently unraveling the knot, strand by strand; then, patiently mapping the results; searching through them for recognizable patterns -- *and then, and only then, theorizing*.

It requires that our first order of business be the collection of individual, objective, experimentally determined one-way light speeds; and it provides a remarkable new design with exactly that purpose in mind. An immediate result of the new approach is that distant simultaneity must become formally re-classified within physics as a secondary, derived concept, and not as a supreme, meta-physical pivot point, as Einstein's approach would have it. By subjecting these experimental results, which for the sake of prudence should be collected from a reasonably large number of relatively autonomous tests, then finally, to some not yet fully specified, new mapping process, the expectation is that one finally should be able to construct a viable alternative.

To better understand both sides of this problem, it may be helpful to remember that Einstein repeatedly remarked that he almost always linked his theorizing to an underlying, guiding belief in the universality of nature's laws. This newly proposed approach, on the other hand, seems to demonstrate far less a priori respect for nature's laws, (except possibly what might be very simply referred to as symmetry) as well as patience with the pretension that we truly understand nature's 'lawfulness' in an entirely satisfactorily manner. Agnosticism about laws might be a better description. Or possibly thinking of at least some see them as 'necessary evils', or as 'training wheels' on Nature's bicycle.

A theory ultimately might turn out to have law-like features, *or it might not*. One might even describe this alternative as making the decision to allow ourselves to be guided by an 'emergent process', rather than by human preconceptions. Is such an emergent process still searching for laws? This is a hard question to answer, because perhaps it assumes in advance that we know more about what constitutes a law than we really do.

But the new approach, contrasting with the older method, would let the data gradually paint the picture, and in essence would put the horse back in front of the cart; theory must not always lead discovery; and not every advance in science must be instigated by some colorful genius -- not in the space age, the age of information, and the age of the digital computer. To an extent, we have all become cyborgs; like it or not.

Furthermore, it seems absolutely critical to insist that the new experimental tests *should not* take place solely on the Earth's surface. For centuries, the primary reason for not testing elsewhere was either that it was impossible, or in the case of using Jupiter's moons or other astronomical features as surrogate clocks, proved to be inaccurate, or else produced such an ambiguous result that it might still be argued to be merely a 'convention' -- just a slightly different one.

The old approach also may have been propped up by a longstanding, purely idealistic, and almost metaphysical belief, one which now may have outlived its usefulness: namely that the earth effectively translates through a virtual infinity of different, relatively moving, perfectly (or maybe just approximately?) iner-

tial frames of reference, during its solar orbit. And from this suspiciously cheap and almost embarrassingly parochial platform, the experiments which have been carried out there have long been presumed to have the power to produce a wealth of information, with a universality nothing short of wonderful -- all without ever leaving home. But this deeply rooted belief could be mistaken. And with our recently acquired ability to send sophisticated instruments into space, no longer should such a pretentious and lazy epistemic gamble continue.

By adopting the new approach described here, any further need for a convention, a stipulation, a definition, or a postulate [10], would be eliminated. The new approach also possesses a methodological transparency which preempts the danger of vicious logical circularity. By contrast, special relativity never has ceased to generate anxiety and perpetually mixed opinion -- even among highly qualified experts. Perhaps no other concept in scientific history has ever generated so much disagreement, or has faced such persistent multi-generational opposition.

Constructing a comprehensive historical review encompassing all this controversy has become ever more difficult, for this remains perhaps the most contentious neighborhood in all of physics. What follows is only an imperfect guide to some of literature considered pertinent by a variety of experts.

The relative novice, but one with an otherwise, strong scientific and philosophical background, might begin with **The Stanford Encyclopedia of Philosophy**, (conveniently located on-line), which contains entries on "The conventionality of simultaneity", [11]; and "Being and becoming in modern physics" [12]. Ten of the primary sources listed in the first article are papers from the journal, *Philosophy of Science*. One particularly inventive paper there was by John Winnie [13]. Others in Winnie's peer group claimed later that his work 'proved' the existence of 'Nature's conspiracy', mentioned earlier. Winnie established a way of treating the Lorentz transforms such that they were free of any one-way light speed convention, even including the one that Einstein stipulated. And his ingenious formulation still did not conflict with either physical evidence, or with natural laws, as they are currently understood.

Along with a number of articles in various physics journals, two other major papers appeared in another important philosophical journal: *Nộus***.** There, David Malament's paper quickly attracted greater attention even than Winnie's had [14].

Many philosophers of science, perhaps even the majority, soon became convinced that Malament's 'uniqueness theorem', introduced in that paper, settled for good the 'conventionality issue' on one-way light speed, and in the negative. The overall thrust of this important development was to disprove, or at least to challenge forcefully and convincingly, the seeming necessity of conventionality originally insisted upon by Einstein. Did Malament's result suggest that Einstein had been more lucky than good? The status of this very peculiar epistemic issue remains unclear today, and is disconcerting by any reasonable standard.

Malament's theorem, in brief, showed that the 'standard synchrony' of special relativity stood out clearly as a type of optimal solution against a range of possibilities, previously conceived of by these philosophers of space-time, as 'all' other viable alternatives. But in this rigorous, well defined context, 'all' meant only those alternate 'conventions' that had been previously identified as worthy of being considered at all by them -- that is, technically, philosophically, and otherwise compatible, not only with the existing physical evidence, but also fully compatible with special relativity, and thus expressible in within the Minkowskian, space-time format.

These other, previously 'viable' conventions *unequally* distributed the time which light took to travel in one direction, versus the opposite direction. But mathematically, they still produced the same round-trip average as all the others in this group.

Critics or outsiders, surveying the quantity of attention which philosophers of space-time physics subsequently wound up devoting to understanding and trying to build upon both Winnie's and Malament's work might suspect heretically that both were long term candidates for becoming red herrings. That is, primarily from a sociological perspective they might be seen, disparagingly, and much later, as having been merely a practical and effective way of demonstrating apparent doctrinal 'progress', or of increased insight into the true features of 'reality', thus bolstering the space-time theorist's morale and optimism that surely they were on the right track. Correspondingly, this would also strengthen their belief that a new way of measuring the one-way speed of light, an objective one, and one which avoided the use of round-trips, in reality, really did possess a vanishingly small probability of ever occurring.

But could this belief be compared by those outside the space-time, doctrinal circle to the encouragingly thin tail in a likelihood curve analogous to the predicted failure rate of AAA mortgage-backed securities in 2007? And if those with the greatest authority and influence become overly confident in a negative belief like this, who is left to mind the fiduciary store?

Jason Zweig, who writes on investing, reported on this common human tendency; others call this 'confirmation bias':

> "Experiments at racetracks have shown that people who bet on an outcome become up to three times more confident that it will occur than people who didn't put up any money."

Considering this truism about human nature, might it not be unwise, then, to ask your local space-time philosopher-physicist for his or her estimate of the probability of a successful, objective, (and disruptive) one-way light experiment? Yet the bulk of commentary on this same subject, naturally, comes directly from those with the largest professional stake in the outcome.

In this case, however, at least one of the most eminent of these space-time philosophers of science, the late Wesley C. Salmon, did have the acumen as well as the professional standing to address this issue directly. Salmon authored the other of the two *Nộus* articles, a long, widely accessible survey, to some extent adapted from his own frequently referenced book, **Space, Time and Motion: a Philosophical Introduction** [15]. Salmon had studied under Hans Reichenbach, who wrote the far more intimidating, **Philosophy of Space and Time** [16]. Unlike Reichenbach, Salmon more openly and directly faced up to the still open possibility that in the future someone might be able to find an "objective" method for measuring one-way speed of light [17].

Salmon did not address the potential ramifications of such an eventuality, however. Indeed, he may not have felt certain about

what they might be. But certainly it would take a tortured interpretation to avoid the obvious conclusion that he meant to imply that such a new discovery almost certainly would fall outside the highly constrained, well defined, epistemic realm in which Minkowskian space-time researchers, like himself, Reichenbach, Winnie, Malament, and many others, all had been concentrating [18].

Perhaps the strongest reason for not being able to rule out this nagging possibility of a future upheaval in their field rests upon the fact that, logically, it is impossible to prove a negative. A wise corollary might be that it is never a good idea to use a negative as foundation for anything important; if possible, choose instead something positive, perhaps in a more Cartesian manner. But Einstein clearly did use a negative as an important component of his foundation for special relativity, and so -- at least it can be argued -- do those following his ideas. To explain: Einstein was careful never to have claimed to have that he *objectively* disproved the possible viability of any other approach whatsoever; nor did he ever claim that all other approaches had somehow been disconfirmed by his own work, en masse. He simply claimed instead that the leading research program of his own time, which he identified narrowly as 'the luminiferous ether', was 'superfluous' [19]. In the same statement, (and seemingly in the same breath), came the assertion that the concept itself was synonymous with an 'absolutely stationary space', -- hence seeming to indicate that the concept had descended directly from Newton's troubling, meta-physical, proclamations about absolute space and absolute time, "without relation to anything external" (to paraphrase). This is a far cry from claiming to have disconfirmed all other conceivable possibilities, including those that may not have been burdened by these suspicious and troubling associations. To give perhaps the best example: probably even in 1905, and certainly since then and right up to the present, a number of theorists have felt that it was improper to conflate all concepts of ether with either time or space, and have argued instead for their categorical separation from what might be 'in' space. That a so-called 'mechanical' explanation of gravity might arise possibly from this kind of research program was a common motivation in this style of theorizing. So from an historical perspective, it is quite misleading to claim that the light carrying feature alone, (*i.e.* through using the exclusive label 'luminiferous") was the only valid explanatory purpose from a theoretical point of view.

From a purely rhetorical point of view, unfortunately, Einstein's remarks can and have been read, as implying that all opponents of his theory are somehow obligated to defend that particular, limited, clearly confused, and archaic approach -- i.e. the so-called luminiferous ether -- along with all the contradictory attributes which 'it' may have possessed historically in its admittedly rough draft form, and to show nevertheless, that 'it' is 'correct'. All this -- all these hoops which allegedly must be jumped through -- in order merely to be on the same playing field as special relativity. Stated in so pejorative a fashion, few would deny that such demands are unreasonable, as well as potentially dangerous, in terms of safeguarding the long-term social benefits stemming from advances in physics. In politics, they call this "defining your opponent". If nothing else, surely it saps the energy of your opponent; for who wants perpetually to be required to teach remedial history to their opposition? [20].

But in spite of such an unfair rhetorical handicap, challenges to Einstein's position continue to appear. In 2009, for example, another proposal for a one-way light speed experiments appeared in the *American Journal of Physics*. Written by three Venezuelan physicists, this paper contains a useful bibliography, as well as a concise retrospective [21]. True to form, it was followed by a purported rebuttal by J. Finkelstein, soon after published in the same journal, and claiming that their proposed method was a tacit round-trip measurement after all [22]. So, this brief exchange was a good example of a microcosm in the macrocosm.

The Venezuelan physicists also complained of "unphysical statements in the literature," and they voiced their objection to proposed experimental tests which allegedly were checking for possible anisotropies in space, but which were joined at the hip to Einstein's synchronization process, and therefore lacked "a logical foundation." With similar disapproval, they quoted from an earlier paper in the same journal by Abraham A. Ungar -- (indeed, this was the paper which contained the earlier, "nature's conspiracy," comment.) Ungar had observed, somewhat innocently, that many on each side of the two professional groups involved, physicists and space-time philosophers, subscribed to beliefs which seemed analogous. As he put it, "Most physicists agree that there is no preferred frame of reference and similarly, most space-time philosophers agree that *light does not have a one-way velocity* [his emphasis]" [23].

Unger attributed this interesting coincidence, on the more philosophical side, to their having been convinced of this by Winnie's paper. Although careful not to claim that Winnie proved his case absolutely or objectively, Unger issued his own tribute more circumspectly by calling the result "a most convincing demonstration." Proof of Winnie's anti-realist contention, of course, again would require proving a negative, and thus would be theoretically impossible except within an artificially restricted domain, which treats the issue as if it were an exercise within pure mathematics, rather than something with a large and unavoidable empirical content.

If the average reader feels a bit dispirited at this point, this would not be surprising. But in large measure, this is more or less how things stand now: a bit confused, not fully settled really anywhere, with different, apparently defensible positions still being held by those currently involved, or still represented by earlier work contributed by those no longer with us, but which continues to be thought of as insightful.

The Stanford article on "conventionality of simultaneity", ended with its own less than sanguine comment, cautiously advising that "the debate about conventionality of simultaneity seems far from settled, although some proponents on both sides of the argument might disagree with that statement." Was anyone left out?

Yes. The outsiders, of course, remain truly excluded from this 'all-encompassing' circle. These critics of special relativity, instead, continue to hope that objective one-way light speed measurement will eventually turn out to be possible; and that it can be performed in a way that satisfies these space-time philosophers. Outsiders also continue to emphasize, with limited success, because of the earlier mentioned sociological and historical

obstacles, that all possible alternate approaches to physics truly have been neither disproven nor unambiguously disconfirmed by the successes of special relativity, and that someday the tide may turn.

True, these critics also believe that simultaneity is not conventional. But they also reject categorically the proposition that Malament's uniqueness theorem gives any objective assistance in understanding why this is so. In effect they predict that this and other related issues, even Winnie's conspiracy demonstration, eventually will become irrelevant. As the philosopher Imre Lakatos might describe it: their revolution eventually might turn into a "degenerate research program."

For the fundamental objective of the physical, one-way light speed experimenters seems to be no less than this*: to falsify what is known as Einstein's Principle of Relativity, the first postulate of special relativity; namely the old Newtonian belief that all inertial frames of reference are completely equivalent for the formulation of the laws of physics*.

Success in proving that inertial frames are not all the same, in turn, would force physicists to treat the physical constancy of the speed of light much differently. The famous universal constant c might undergo such a complete transformation that it might wind up being substantially analogous to sound velocity, despite the fact that its waves are transverse rather than longitudinal, the original stumbling block and scientific pivot point. Such a development, of course, would also make a strong statement about how little we understand nature's laws.

Also, if such new disconfirming physical evidence were to emerge -- and with this new proposal, there certainly exists such a possibility, (at least its inventors certainly harbor that hope), then it could not be circumvented, ignored, or buried under a mountain of additional, confusing, philosophical back-and-forth.

This seems a fair generic description of the general history of this subject, in which the infamous twin paradox certainly must be included, with its endless accusations of problematic symmetry. Supporters of special relativity consistently retaliate by saddling its critics with what they see as impossible entailments of absolute rigidity or of equally impossible, instantaneous signal transmission. The critics deny these entailments are necessary components of their arguments. This new experimental proposal, remarkably, seems to have avoided this pitfall. Also, the kind of circularity that might be identified as 'vicious' seems to have been avoided. Of course, the validity of the proposed approach remains to be fully evaluated. Space-time philosopher-physicists have every right to contest this new proposal -- for this is part of a healthy process.

Finally a note of caution, aimed at historical accounts and especially upon the wisdom, particularly for newcomers, of relying upon them uncritically: some of the first physicists to express skeptical thoughts and to offer frank, honest, criticism of special relativity, not only were Einstein's contemporaries, but even his good friends. And not all of these highly qualified theorists ever changed their minds. But those seeking an unbiased and clear understanding on this point, easily can be misled through uncritical reliance upon the objectivity of physics historians in general. Much of the historical material which has been written describing the so-called 'space-time revolution', has been overly enthusiastic (to be diplomatic). The human tendency to nudge the provisional into the realm of the eternal is labeled "Whiggishness" by professional historians. To single out one particularly egregious example (referenced earlier above): Einstein himself co-authored a purported introductory physics history in 1938, together with Leopold Infeld [24]. Chances are good that anyone with even the slightest interest in physics has read this book -- typically as an early introduction.

But, taken from politics, consider this brief cautionary tale: When Ronald Reagan was President of the United States, Donald Regan, first his Secretary of the Treasury, then Chief of Staff, left in a storm of acrimony, a young reporter naively asked him "if he thought history would be kind to him?" Regan had a ready answer. "Yes," he replied, "since I intend to write it."

So to compensate, albeit only feebly, for this systemic, and many feel, unavoidable bias contained in almost any historical subject, the reader is encouraged to take especially good note of the fact that Lorentz, Einstein's good friend, never agreed with Einstein's anti-realist stand on simultaneity. Nor did Poincaré agree with this radical idea, even though he has been accused (or credited -- depending on point of view) of having earlier, somewhat similar ideas [25].

Lorentz lived until 1928 -- long enough to give the matter plenty of thought. Poincaré, died in 1912, at age 58. That gave him seven long years to think things over. But he never said a positive word about Einstein's peculiar idea. Poincare's death was also a sad echo of Maxwell's similarly premature death at age 48, in 1879, the same year Einstein was born; for a thinker as great as Maxwell might have weighed in perhaps with another interpretation of the Michelson-Morley experiment, one which might have conflicted with Einstein's, and led in different, more productive directions. More about this possibility comes later.

But Maxwell, Lorentz and Poincaré, in actuality, were the inspired individuals who created the mathematics that later became substantially re-interpreted in the 'space-time revolution'. Their opinions concerning the existential and causal entailments of their own mathematical creations should not be dismissed lightly, no matter how compelling the reasons. Furthermore, at least some would argue that there are good reasons for supposing that none of these three, ultimately, would have joined this revolution and endorsed the reality of space-time.

3. A New Method

This Section discusses a new method for one-way light speed measurement, and for determining whether a given inertial system of motion is isotropic or anisotropic.

Two researchers, JinXi Dong, of the Bejing Institute of Petro-Chemical Technology, and Bo Dong, of the Bradley Department of Electrical Engineering, at Virginia Tech, have published a 2011 article in the journal *Physics Essays*, (published by the *American Institute of Physics*). Their title is, "A Theory on measuring the one-way speed of light and a method of verifying the invariance of light speed" [26].

This paper outlines their ingenious new theoretical exploitation of a long available electro-optical instrument which was first used in light velocity measurements by Otto Mittelstaedt, in 1928. Since then, at least two other light velocity experimenters have used the same apparatus in their work, seeking greater pre-

cision. The pioneering work that set the still-evolving, developmental process into motion is credited, circa 1875, to the Reverend John Kerr (1824-1907).

The Kerr effect is based upon a change in the refractive index of a material that is responding to an applied electric field. It can interrupt a beam of light up to 10^{10} times per second. The genie in the bottle, liberated by the new approach, and believed by these designers to be ready and able to be pressed into this new and innovative service, is the Kerr cell 'doubled'. Two of these devices appear in tandem in Fig. 2, reproduced from the original paper of the researchers, and are labeled A_K and B_K.

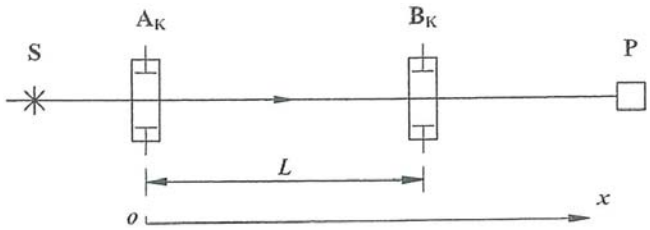

Fig. 2. First Experimental Configuration: The scheme of experimental setup.

The entire apparatus must be maintained in a vacuum; the reason is the differing speeds of the color components of ordinary light, versus a vacuum. In Fig. 2, power in the form of light is emitted from a source, S. When light passes through the first Kerr cell, A_K, it is modulated sinusoidally. This creates a newly configured, continuous signal as its output, which simply repeats itself from cycle to cycle. Next, this modulated signal passes through a second, identical Kerr cell, B_K, a cell that is being maintained at the same exact operating frequency. The photo detector P records the final output curve.

Fig. 3, is a small sample of about two cycles of such an output. The most significant aspect of this signal fragment, for purposes here is that it could also have been produced from a substantially different experimental set up, one containing only single modulating Kerr cell, rather than two of these optical devices, in tandem, as in Fig. 2.

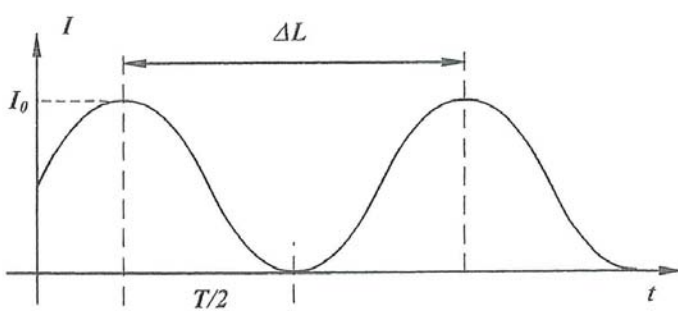

Fig. 3. Light intensity variation at a certain point on the axis.

To create such a seemingly unlikely result -- an apparent maximum output even when both cells together modulate in sequence, can occur only under a special condition. *Only when the second Kerr cell is precisely positioned such that no additional modulation from the second Kerr cell actually takes place, can the final output produced be made to appear like the result illustrated in Fig. 3.* And to reiterate: both Kerr cells must be operating at the same frequency. This requirement is absolutely critical, and must always be satisfied for the outcome to be successful.

Next, imagine that the right hand Kerr cell is mounted on a steel track, so that it can be moved by turning a crank which also is linked mechanically to a micrometer. This way, the real-time effect of slowly and gradually increasing the distance, L, can be correlated with the co-changing output, as registered by the photo detector. As this distance becomes larger, the experimenter searches for the first available position where the output produced by the photo detector is at a maximum.

Once this maximum appears, the experimenter marks this position as B'_K in Fig. 4.

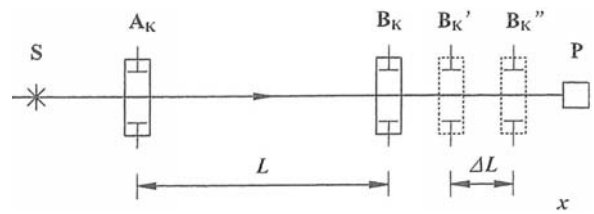

Fig. 4. The measurement of the light pulse, or "cycle length," ΔL.

The position of this Kerr cell, B'_K corresponds to the position of the first peak in the sine wave shown in Fig. 3, on its left hand side. Continuing the Kerr cell repositioning process, the next available maximum position is located and marked as B''_K. This second new Kerr cell position corresponds, referring again back to Fig. 3, to the dotted vertical line on the right. The distance between these two positions, ΔL, is interpreted experimentally as the physical length of one full modulation cycle. The one-way speed of light between the two positions and in the direction of the signal is simply ΔL divided by the operating frequency shared by both Kerr cells. In order to determine the one-way speed of light in the opposite direction, the entire experiment must be turned around 180 degrees and repeated.

As an aid to reader visualization: the length of a single cycle, ΔL, typically will turn out to be about 30 cm, or one foot. The mathematical calculation consists of the speed of light, which is approximately 3×10^{10} cm/sec, divided by the actual operating frequency of the Kerr cell. Typically, this was reported in the original paper as being around $10^9/\text{sec}$. The researchers also have noted that a higher frequency, up to $10^{10}/\text{sec}$, may be possible, thus creating a ten-fold reduction in cycle length. But this may increase the difficultly of measurement. A second, experimental arrangement exists however, to be described shortly, where this might be advantageous.

Positions B'_K and B''_K can now be thought of as being 'synchronous', that is, being *both* in phase *and* operating at the same rate or frequency. Also, the issue of distant simultaneity between these two "distant" positions, now can be addressed. In principle, even the old method of exchanging light signals for synchronization still would be acceptable, except that now the objectively real light speed differences between opposite directions must be taken into account.

A real physical difference between the lengths of the two ΔL's/frequency values collected from two independent operations in opposite directions would be interpreted to mean that

light speed is *anisotropic* in that shared reference frame. If the two measured lengths turn out to be equal, then it is *isotropic*. Essentially, the frame of reference is being compared o*nly to itself*.

Also, it must not be assumed that its validity can be extended, outwardly into the physical universe, all the way to infinity, as historically so often theorists apparently have felt licensed to do without adding any additional empirical justification. The current experiment should be thought of as a comparatively 'local' measurement. But the intended meaning of 'local', in this context, is far more practical and empirical than it is philosophical. Also, this word meaning does not comport well with the use given by Einstein in his own discussions of simultaneity, where he seemed to have used "local" effectively to mean confined necessarily to a single, infinitesimal point.

To explain: A given system is judged either isotropic or anisotropic: fish or fowl. Over how great a distance this judgment is thought to be valid, should be considered an entirely empirical, practical matter, to be decided strictly through hands-on physical investigation, and certainly one not to be specified in advance purely by mathematical fiat, or (more to the point), by mathematicians usurping the prerogatives which should be accorded rightly only to physical scientists, those who are expert in error analysis and instrumental reliability. Nor should it be assumed the issue has been dealt with competently at earlier times in scientific history. Also, a system which has been determined to be locally isotropic should not be conflated with some kind of universal "system of rest," one which also can be extrapolated ad infinitum safely. From the standpoint of making science as objective as is possible, this is a pretentious and unwarranted assertion, springing from overly speculative, out-dated physical analogies, and perhaps from an insidious sort of Platonic, intoxication with pure mathematics.

Kerr cells, when operating properly, may be regarded as "clock-like." For example, they might be thought of as clocks without hands, or perhaps with just a single hand for seconds. Like stop watches, the ones commonly used at track meets, they could have a cycle counter. When the frequency of a Kerr cell is known, and its frequency is also known to be stable, then something very clock-like certainly seems to be in play. This stop watch function actually makes a working appearance later, when Einstein's long train thought experiment is revisited critically.

The two researchers offered this philosophical overview:

> "Therefore, in an inertial frame, when the light propagating in [a] certain direction with the constant speed is modulated periodically, it becomes not only the object whose speed is under measurement but also a medium that transmits the time information, from which a novel theory of one-way speed of light measurement is acquired" [27].

In the earlier quotation, Einstein commented that our being able to answer physical questions about one-way light speed would "only be possible if we already had at our disposal the means of measuring time." But what the researchers have described above seems to be exactly what Einstein has requested. Their own new and novel method of measuring time now seems at our disposal, ready to replace Einstein's provisional assumption, should it prove itself more useful and objective. One might think of the new experimental procedure heuristically as an optical sausage making machine, to get away from the less visually accurate sine wave abstraction: i.e. the size of the sausages produced is in ratio to the speed of light in the direction in which specific sausages are being produced. Another purely visual aid for understanding might be to add a mirror image (below the original and upside down) to the "naked" sine wave actually presented, so that it waxes and wanes in terms of the actual volume encompassed over time -- zero at the minimum and 100 percent at the maximum. On the printed page, this three dimensional change still must be condensed into just two dimensions, but this should give the reader a "truer" picture."

Concerning possible error due to the repositioning movement, as referred to earlier, mathematical calculations by the two researchers purport to show that if moving first to B'_K, and then onward to B''_K, somehow causes the frequency of the Kerr cell to change slightly in what critics might claim to be "time dilation" (using the conceptual and linguistic framework of special relativity), then such an effect would be too small to have any substantive effect on the outcome and integrity of the experiment [28]. To go more deeply into this kind of issue involves difficulties which exceed the capacity of this paper to resolve. Besides, even attempting to do so might interfere with its intended wide accessibility, an earlier stated goal.

Before leaving this subject however, there is a subject worthy of notice: although the two researchers, themselves, gave no official citation of a seemingly related historical episode, the overall manner in which they have written their paper makes it likely that they were well aware of it, regardless. To be sure, their claim of an insignificant effect from motion will surely draw special attention from those familiar with this. Circa the late 1960's, it had been argued that slowly transported clocks might be used to establish a different synchronization result than the one specified by special relativity. This culminated with a panel discussion that was published in *Philosophy of Science* [29]. The consensus finally reached was that, in the end, this method was mathematically equivalent to Einstein's original procedure.

But here the situation seems substantially different. First, the researchers claim that any hypothetical error-producing effect will be dominated effectively by the comparatively greater size of the effect being sought. They provide a mathematical argument to that effect. But they also seem to claim that the protocol of frequency monitoring provides an additional safeguard. It seems difficult to separate these two claims.

Fortunately, for the sake of keeping things as simple as possible here, a good reason shall arise later in the paper for not making any attempt at resolution. Within the second experimental configuration proposed by the two researchers, a strong and hopefully convincing argument for ignoring this problem altogether can be constructed. Producing an account of this will have to wait, however, until after the second configuration has been introduced, and described in sufficient detail.

Similar to the adoption of an agnostic position on the effect of movement, the position adopted in this paper, also for practical reasons, has been not to attempt to attempt to pass judgment upon the experiment's technical feasibility. Nor shall an explanation of many of the finer details of the operations it requires in order to achieve such success be given. Scientifically adequate

projections of accuracy and reliability are simply too complex to treat adequately here. This type of extremely specialized analysis must be left to persons expert in this esoteric sub-field of physics. Hopefully, qualified experts will publish on these issues in the future. As stated in the abstract, the objective here is merely to convey to a wide audience, a conceptually faithful illustration of basic ideas contained in the new approach. And to do this with the clearly stated assumption that the conceptual core of the method, at a minimum, does seems sound enough and original enough to be worthy of further consideration and discussion. For a brief illustration of how difficult it would be to proceed otherwise in this paper, consider the following passage covering just some of the technical problems that must be addressed successfully. After considering this passage, there ought to be little need for any additional commentary by this writer. For the thrust of this difficulty should have been conveyed adequately.

> "Obviously, I' [the intensity of light passing through B_K] is a high frequency signal confined by a low frequency envelope with a period of $1/\Delta f$. Therefore, if the two Kerr cells are modulated by two signal generators locked to oven-controlled crystal oscillators whose uncertainty are typically 1×10^{-12} and the modulation frequency $f = 1\,\text{GHz}$, the averaged signal acquired by the photo detector P varies slowly with time at the frequency of $\Delta f = 1\times10^{-3}\,\text{Hz}$, which corresponds to the period of $1000\,\text{s}$. In order to secure accuracy, the measurement is suggested be completed in at least $1/100$ of the period which is $10\,\text{s}$. Fortunately, by employing the newly developed optical frequency combs which reach the bottom level of uncertainty down to 10^{-19}, the measurement can last up to 10^{8} s. This shows that the new development of technology has provided the possibility for the method." [30]

Fig. 5 shows the second experimental arrangement. This method is intended to more easily produce a statistically significant determination of whether a given inertial system is isotropic or not—a simple 'yes' or a 'no'. Referring to their first experiment, the experimenters, comment that, "it is very hard to differentiate the precise difference between the light pulse lengths in different directions by measuring the length of ΔL." In fact they think it may be impossible in reality in the laboratory. This accuracy problem seems to be have been part of their motivation for developing their second method -- for it is one which requires less accuracy. This is not to imply that numerical one-way light speeds cannot also be derived from it as well; but these values might be less accurate than the first method, if it turned out to be feasible technically. Another practical advantage of the second method also is that this configuration is already fully symmetrical and does not require reversal.

In Fig. 5, there are two separate power sources, A and B, each aimed directly at the other. When the two signals each encounter the respective, first, semi-reflecting mirror, (both mirrors are marked M, to the left and right), a portion of each passes through the Kerr cell directly its path, then both signals continue onward, next passing through the other Kerr cell. Thus, the light signals pass directly through each other. Each signal then, undergoes modulation twice, then is reflected downward by its second mirror encounter, then its strength is registered on each side.

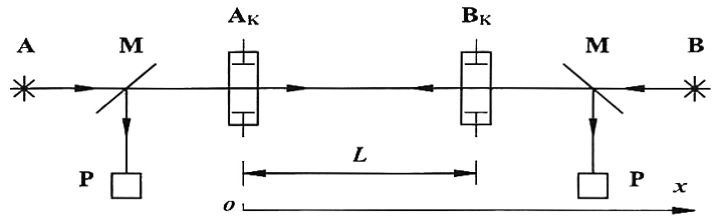

Fig. 5. Second experimental configuration: A two way Kerr cell experimental set-up for testing whether light transmission isotropic or anisotropic in a specific inertial system of motion.

If the Kerr cell cycles produced on one side of the experiment are smaller in length than on the other, then accordingly, the one-way light speed of that same side also will be smaller than that of the other side—even though the rate of cycle production by each of the two Kerr cells, on either side, always remains the same as the other. Correspondingly, the side with the longer length cycles would have the greater speed. In such an *anisotropic system*, one-way light speed in one direction would be in the ratio $c+v$, to the opposite direction having speed ratio of $c-v$.

Initially, imagine that the experiment begins with the two Kerr cells positioned relatively close to each other, such that approximately an integral number of cycles separates them, but still allowing for a small discrepancy δ. No longer should they be regarded as being quite so precisely in phase as was the ultimate design objective in the earlier case. The first experiment was to eliminate δ more directly; but with the new design, a different strategy aims at obtaining effectively the same outcome. How this is done should become clear later on.

Again, both cells must be maintained at the same operating frequency. It should also be kept in mind, that this protocol has been licensed in effect by Einstein's "further physical hypothesis," cited earlier.

Each of their oppositely directed, 99% plus of maximum outputs may be thought of as "perfectly" (*i.e.* within limits of normal experimental error) superimposed upon each another when they pass through each other at the precise moment captured by Fig. 3. This makes it possible for the sine curve of Fig. 3, to serve a new illustrative function. Originally it stood for two possibilities: just a single signal moving in the rightward direction, and at that time passing either through just one Kerr cell, or possibly two Kerr cells in tandem, as earlier explained: provided that the second Kerr cell had no additional modulating effect.

Now, Fig. 3. also can be thought of as representing an instantaneous snap-shot of two superimposed signals traveling in opposite directions.

But in terms of the expected 99% plus outputs, it would also be possible to set up this experiment initially in a substantially different way. Imagine the following: that the two Kerr cells initially had been placed so that they were separated by a total distance of roughly 45 cm, or one and a half cycles, as represented by the distance from the first dotted vertical line to a new, third, dotted vertical line, which appears in Fig. 6 at the extreme right.

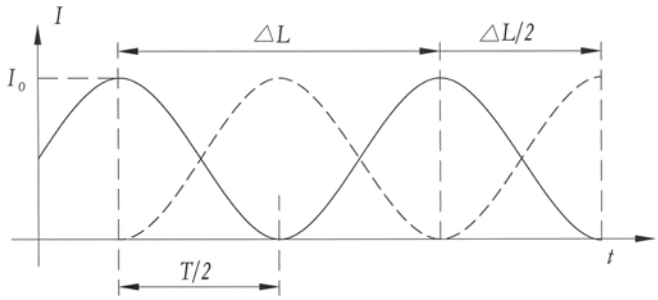

Fig. 6. Changing Kerr cell positioning in an isotropic system from maximum to minimum signal passage on both sides -- the result of increasing the distance from one cycle to one and one-half cycles. (This arrangement might be called the "Double Kerr Roach Motel.")

In Fig. 6, the dotted sine wave should be visualized as travelling in the leftward direction, while its solid counterpart is moving rightward. Again, as before, each Kerr cell, must be in the 'open' part of its cycle at the exact two instants which are portrayed by the first and third dotted vertical lines in Fig. 6.

Following this wave motion in each direction shows that the initial positioning causes each signal to arrive at its own second Kerr cell when both of them are closed. Thus, both photo detectors will record a *minimum* strength signal.

Between these two extreme positioning arrangements, one high and one low, (Fig. 3 *vs.* Fig. 6) one can also imagine the right hand Kerr cell being moved in a series of smaller increments between these two positions. On each side of the experiment, then, an observer would witness a changing sequence of perfectly matching partial strength signals appearing simultaneously on each of the two photo detectors. The two outputs consistently would be identical: i.e. at 1/8, the other would be 1/8; at 1/4, the other would also be at 1/4 … 3/8 … 1/2 strength, etc.

This would be analogous to watching the phases of the moon develop over a one month cycle. The 'moon', in this case, starts out 'full', both on right and left sides, provided that the first distance recorded was produced at a one cycle distance between the Kerr cells (Fig. 3) (or alternatively, by an integral number of cycles, as explained). The 'new' moon, on the other hand, would be correlated with the greater distance of 1 & 1/2 cycles (Fig. 6), (or another integral number, plus one half). At this point both photo detectors would display minimum output.

The above sequential imagery, once understood clearly, should enable the following result to become clear: *in an isotropic case, precisely the same result on each side would be recorded simultaneously, in observation after observation by both photo detectors, cycle by single cycle, as the distance between the two Kerr cells gradually became increased, and both outputs, at the same time, were monitored continuously by the photo detectors..*

This holds true for as long as the precision of the apparatus can be maintained (*i.e.* but not ad infinitum, as previously noted). Even with a great increase in distance, this property of single cycle, mirror symmetry would persist. Of critical importance, however is the fact that this is not at all the case with an anisotropic system.

Instead: *an anisotropic system would show a building, cumulative, multi-cycle, gradually changing difference in amplitude between the two signals, also as recorded by the photo detectors, as they are compared to each other. An "inflection point" finally will be reached, where one photo detector would detect a maximum, while at the same time, the other would detect a minimum. At that, readily identifiable inflection point, the same pattern would begin to return to where it began, then would begin yet another such cycle.*

To help in visualization, and rather than providing another figure for reference at this point, (for this task becomes somewhat easier later on in the paper) the reader can visualize instead a straight row of ten pennies, laying flat on a table top, next to an also straight row of nine nickels. If the two rows each start out with their bottom edges matched perpendicularly, then this agreement of their respective edges will systematically erode with increasing distance. The leading edge of the fifth penny, for example, will reach only to the mid-point of the fifth nickel. Since the total length of ten pennies equals approximately nine nickels, at that point, the two rows regain their edge agreement. This 10 to 9, cycle will simply keep repeating if more coins are added. Generalizing this result: using the second experimental configuration, an inflection point, similar to the one in the coin illustration, would occur when the faster light speed direction has gained one half of a cycle, versus its slower, opposing counterpart, as the total distance between the two Kerr cells gradually was made greater. The information provided by the experiment also suffices to establish one-way light speed values in each direction mathematically in the form of ratios, but merely showing isotropy of anisotropy in a given system is its primary claimed purpose, according to the researchers' paper. They also claim that such a qualitative result does not entail dealing with so-called time dilation in its required movements.

Perhaps the first use to which this experimental set-up might be put might be: either to verify or falsify the anisotropy of a specific system, as predicted by a particular theory. In fact, the researchers propose just that. But this writer strongly disagrees with the specifics of their proposal, for they propose basically an experiment on the face of the earth which has same underlying theoretical assumptions as the ones used in the Michelson-Morley experiment. As argued earlier, these are outdated and unsound theoretically; even worse, they seem to imply no other experiment in a different frame of reference would be needed to ensure a definitive, objective result.

Specifically, they argue that if, in an experiment using the same underlying assumptions as the ones in the original Michelson-Morley experiment, then another "null" result -- one basically showing that light velocity is isotropic on the earth's surface -- were the result, this would be yet another "confirmation" of special relativity. Their own clearly stated expectation, of course, is that "the speed of light is variable" [31]. Therefore, their own expectation, or prediction, is a non-null finding of anisotropy (just like Michelson's *before* he conducted the experiment), and thus an outright disconfirmation of special relativity. This writer disagrees.

For the reasons already stated, this writer believes firstly that tests absolutely must be conducted elsewhere, in other inertial systems, whether or not these are supplemented partially by a test conducted on the earth's surface. Secondly, it must be pointed out that since special relativity requires that all tests conducted elsewhere, in different, relatively moving inertial frames of reference, similarly must produce a null result for special relativ-

ity to survive. For example: in Einstein's train experiment, both train and embankment must produce the same result.

But this, quite clearly, should be recognized as logical impossibility, using the inherent logic of their own experiment. Two different inertial systems, each possessing a relative motion with respect to each other, in the same vicinity, cannot both give a null result. *Only one of them can.* This will be demonstrated clearly and unequivocally in the paper's next section.

But prior to moving on the paper's next section, the second experiment's details deserve some additional explanation: first, the exact distance at which the hypothetical one half cycle gain ought first to occur, using this second approach, would be calculated though application of an external, independent theory. For their own proposal for conducting a Michelson-Morley type experiment -- something certainly which meets such a criterion, even if the wisdom of using it might be questioned -- the two researchers calculate that the half cycle gain would occur at a distance of 750 meters; and that at 1500 meters it would disappear, and so on. This calculation assumes a Kerr cell frequency of $10^9/\text{sec}$. But with a frequency of $10^{10}/\text{sec}$, they calculate that the distances could be reduced, helpfully, to 75 and 150 meters. They also point out that the initial lag due to whatever imprecision was the case initially, and has no way of building up or multiplying. This effectively cancels its importance, and it also explains why something like the multi-stage process described in the first experimental configuration (which is designed to remove it) no longer is necessary. Here " δ ", does not threaten the validity of the result, as it might when two very small distance values are to be compared far more directly (*i.e.*, as in the first experiment).

If the data collected near that point turned out not to be particularly sharp, (not at all unlikely in a physics experiment of this type) a suitably large number of separate trials in the vicinity of this suspected inflection point might be subjected to a more sophisticated, statistical analysis.

While the experimenters did not specifically address the role of advanced statistical analysis in their original paper, they may have left it to be discussed in a future publication. At any rate, such a data-handling technique certainly could be integrated into the final engineered total "instrument," essentially creating a bootstrapping effect that might boost the confidence level of the results. Of course, this type of statistical processing is widespread, and especially common in particle physics.

Now the earlier question of what knowledge Einstein's "further physical hypothesis" actually licenses, in terms of what can be extracted from it, via logical extension, finally can be addressed. Does this hypothesis *alone*, whatever its epistemic status, contain sufficient information to avoid dealing, first, with the issue of distant simultaneity, hence any issue of conventionality, *etc.*? Specifically, can we expect to find out whether a given inertial systems is either isotropic or anisotropic, without the benefit of any previous knowledge of distant simultaneity whatsoever? According to the totality of what has been presented here, the provisional answer seems to be 'yes'. For at the very least, the Kerr cell second configuration makes possible the following experimental test, a test which does not require knowing any precise distances anywhere in particular: *In a given inertial system of motion, by using the second Kerr cell experimental design, the gradual appearance of a stronger signal in one direction and a gradually weaker signal in the other direction at the same time, in principle, at any distance whatsoever, between the two Kerr cells, as the distance between them gradually is increased indicates anisotropy. But a finding of an equally balanced output in both directions, also at any distance whatsoever as their distance is increased, is evidence supporting isotropy.*

The next order of business is to return to Einstein's long train thought experiment, and to show that it is incommensurate with the new experimental approach.

4. Einstein's Train Again

This modification, or "deconstruction" (in the currently popular idiom), of Einstein's original thought experiment begins with a critical assumption added to Einstein's original requirement of inertial frames for both train and embankment. It is the following: let us assume initially that *only the embankment observers* have conducted extensive experiments previously, using either, or both, of the new Kerr cell design configurations, and that their experimental results have indicated unequivocally that the embankment is a system with truly isotropic light transmission properties. Deliberately, the train initially has been excluded from this experimental process.

The next problem is to superimpose the entire new methodology upon Einstein's long train example. In this way, their incommensurability can be demonstrated.

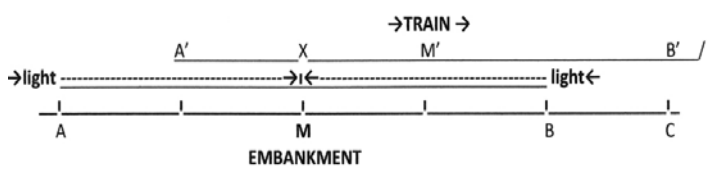

Fig. 7. The revised, very fast, short train, thought experiment.

In Fig. 7, the train's velocity has been increased to one half the speed of light. This modification has the sole purpose of allowing the argument following to be as clear as possible. Surely, Einstein would have no objection to the proposition that his train might have any speed; no substantive change in his meaning would result. Previously, there was nothing at all objectionable in his requirement of a very "long" train; but now, through assuming a rather large increase in the train's speed, Einstein's original reason for giving the train great length has been made unnecessary. For now, the accumulation of what Einstein intended as merely a tiny, discernible, separation between the two respective mid-points, M and M', in Fig. 1, a separation which could be revealed, at least in principle, by a "real" experiment -- that is, if one wished to go to the trouble and expense -- has been replaced by the creation of a comparatively huge separation.

The new separation, in fact, amounts to half the distance from either A to M, or from M to B. It also equals one fourth of the total distance between the two original points A and B, where the two lightning strikes originally occurred.

Concerning the relative 'shortness' of the train, this simply implies that the necessary scale, (*i.e.* the real distance between A and B, if one were to actually calculate what would be needed in reality), now can be much smaller than the implied enormous

length that Einstein's example truly demanded in a realistic sense -- in order to create a reasonably discernible effect.

The next step is to imagine that, aboard the train, moving with it, at the train observer's "fixed" points A' and B', of Fig. 7, Kerr cells also have been made available, belatedly, for similar experimentation. Let it also be assumed that these Kerr cells are equipped with a "stop-watch" function for counting numbers of cycles which pass during well defined intervals. Once again, this is not to claim that this stop-watch function converts these Kerr cells into ordinary clocks, the kind which "tell time". Instead, it merely enables an observer to count how many "ticks" accumulations between visual observations of the same physical landmarks pass by. These landmarks already were provided in Einstein's original example.

Finally, let us assume that as the Kerr cell toward the rear of the train travelled from position A/A', at the time of the initial lightning flash nearest it, to a new position A', (the position shown in Fig. 7), it had emitted exactly 10 cycles. Secondly, assume that when the lightning flashes met at X/M, the leading edge of the first Kerr cell cycle, emitted originally from position A/A', also arrived there simultaneously.

Therefore, *at least in the spatially extended world of the embankment*, at that particular instant in time, those observers would conceptualize the entire 10, full cycles, still on their way, and stretching the entire distance $A'X$, continuously and sinusoidally.

Embankment observers, therefore, would describe these signals both objectively and physically as having been compressed by 50% as a result of the train's "real" motion, compared to what their lengths might have been, instead, if they had been emitted from a train which was moving more slowly, or even stopped somewhere on the embankment.

5. Thinking outside the Box

As a potential source of confusion, it must be emphasized that this exercise contains absolutely no kind of internal assumption about the effect of motion on Kerr cells, much less the same kind of effect on ordinary clock rates; *nor effectively does it ignore them, as will become more clear in this conclusion.* Effectively this type of issue -- endemic in virtually all discussions of special relativity -- has been sidestepped here altogether; the analysis here is intended to be an exercise in thinking, as the expression goes, "outside the box." In present context, never is there any need to compare clock rates, or relative lengths for that matter, back and forth between train and embankment. By deliberate design, these types of measurements have been isolated and made unnecessary -- at least temporarily. Of course, they will need to be addressed subsequently, once the question of how they should be treated causally has been reconsidered, and treated differently. Remember: Kerr cells are not ordinary clocks; they can be adjusted freely to a wide range of frequencies, as needed.

The critical point to remember is that when Kerr cell modulated signals of any frequency, whatsoever, have been emitted from both left and right positions on the embankment, previously it has been assumed that this system was previously, and where it was found to have exhibited an objective, left to right, mirror symmetry. Again, this assumption only applies to the embankment, and not to the train. It should be considered "licensed" in exactly the same spirit in which Einstein assumed that both of the idealized systems which he chose to use -- his own train and embankment systems -- were ideally inertial. Certainly, his assumption has always been accepted as a permissible idealization for a thought experiment. Therefore this present assumption should be equally unobjectionable.

Now, returning again to the moving train: From the right side, from the Kerr cell at B', in travelled from its previous position when it coincided with B on the embankment, until it coincides with C, on the embankment, let it be assumed also that 10 cycles similarly were emitted during the time interval between these two position. And just as was the case previously, when the leading edge of its first cycle arrived at X/M, these 10 cycles, therefore, also could be pictured as being in transit, at that same, frozen moment *in embankment time*.

This second group of 10 cycles, then, has been elongated by 50%. The total length of these 10 cycles according to the embankment observers is now XB'. This happens to be three times the physical magnitude of $A'X$ (Fig. 8).

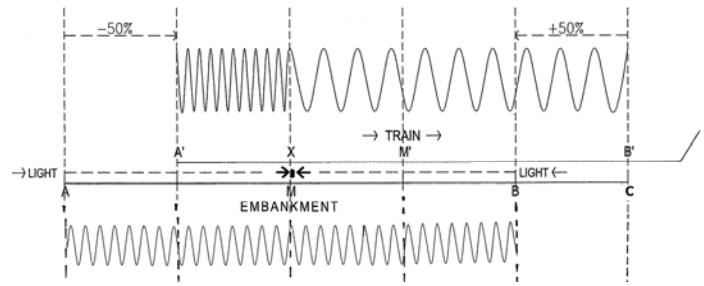

Fig. 8. Combining the modified train experiment with the double Kerr cell experiments.

On the top of Fig. 8, two sine waves, intersecting at X, and possessing distinctly different frequency appear. On the bottom, however, there appears to be just one, single wave, stretching all the way from A to B. In reality, however, this bottom wave really consists of two separate waves coming together from opposite directions, each meeting the other, at M/X.

The bottom wave produces the appearance of being a single wave as a direct result of the objective symmetry which has been stipulated as existing there, physically, from left to right -- the clearly specified underlying assumption of this revised example. But such objective physical symmetry clearly is not the case at the top of Fig 8.

The frequency of the bottom wave also is noticeably different from either of the two frequencies appearing at the top. This too has been done deliberately. Furthermore, the bottom amplitude, (or signal strength), appears to be only about half the top amplitude, an amplitude which for the opposing two waves coming together at the top, is exactly the same.

All these differences were created deliberately, and purely for illustrative purposes. The objective of proceeding this unusual way has been to make it more difficult for the reader to make quick, quasi-numerical, translations between top and bottom systems. Comparisons like that, between different, relatively moving inertial frames are common in the teaching examples which illustrate special relativity, along with careful mathemati-

cal equations, provided so that the student can keep various things straight. But emphatically, this is *not* the program here.

Remember: the two different sets of experiments which have been described here, 1) initially on the embankment; then 2), and only later, on the train, each were conducted independently -- and by two completely different sets of observers. Therefore, each group of experimenters-cum-observers (train or embankment) has been free to choose whatever Kerr cell frequency they wish, as well as what specific level of original power input. So in this revised example there is absolutely no need to translate any specific numerical values back and forth, between these two systems of motion. In fact there is no need, right now, even for any theoretical speculation on precisely what complications of this type it might be necessary to deal with later. Should this become necessary later, it would be for completely different, disconnected purposes, from those pursued here.

Summarizing, Fig. 8 was designed for the purpose of exhibiting a clearly necessary, objective, physical symmetry difference *which must exist* between any two inertial systems of motion that are moving with respect to each other (like the train and the embankment), and nothing more. The bottom sine wave exhibits a type of perfect mirror symmetry from left to right which is *absolutely and objectively* dissimilar to the symmetry relationship existing between the upper, left and right, sine waves, however those two waves might be described.

When the two opposing sine waves at the bottom meet at point X, and begin passing directly through each other, then once per cycle, they will be perfectly superimposed, and will appear exactly the way they appear in Fig. 8. This kind of graphic multitasking, where more than one underlying reality might actually be the case, and is not possible to unravel the true situation with certainty unless additional information has been made available, has been encountered earlier. Figs. 3 and 6 earlier were used for illustrating this kind of situation. But such perfect super positioning properties are characteristic *only of an isotropic inertial system, and do not exist objectively in anisotropic systems.*

So this is a case in point: for the two upper waves in Fig. 8, one travelling leftward, the other travelling rightward -- about to collide-- the symmetry situation is dissimilar to the perfect symmetry exhibited at the bottom. Once these wave begin passing through each other, never will there be a moment when they can be said to superimpose like the ones, below, on the embankment.

And while their *absolutely objective three to one size ratio*, of course, might possible be revealed, in principle, by using the first Kerr cell experimental configuration, illustrated by Fig. 4, or the second type of experimental operation, again in principle; it should be unnecessary at this point, however, to specify and describe each operational step in some such experimental process in full detail. This is the reason for use of the word 'logic' in the paper's title. For this is basically a problem in de-coding. The signature of what is to be read here, this objectively real anisotropy ratio, is a man-made energy field map, an interplay of different intensities of light, having passed in opposite directions through two Kerr cells operating at the same frequency. And ultimately this purpose-laden, human creation may make it possible to differentiate *objectively* an anisotropic system from an isotropic system. Furthermore, doing so, clearly, will not involve first dealing with the problem of the rate changes of clocks caused by motion, partially discussed earlier. Why should nature be constituted in such a way as to conspire to keep us from doing this? Barring any demonstration otherwise, this methodology should be outside that alleged box.

This type of decoding almost certainly will involve searching at pre-calculated positions with an instrument that incorporates the design principles embodied in the two Kerr cell configurations described here. Once placed in relevant positions, identified by the theoretical calculated characteristics of the suspected anisotropy "signature", the previous movement history of whatever device may have been created with which to measure respective power levels from opposite sides should be as irrelevant as the individual temperature histories of the different materials from which it was made. After having positioned such a device in a thought-to-be-productive location, based upon theoretical suspicions, the first order of business would be to measure its frequency for accuracy before placing it into operation. This careful, systematic approach appears to eliminate any concerns about the detrimental effect of motion on Kerr cell rates and how this might invalidate the outcomes.

The perspective that this paper has attempted to provide is predominantly logical. Whether and exactly how, a verification step actually might be accomplished, from a real experimental perspective, at present, is not possible to specify in advance -- probably not even for an expert more qualified than this writer, or even by the two men who created the design principles.

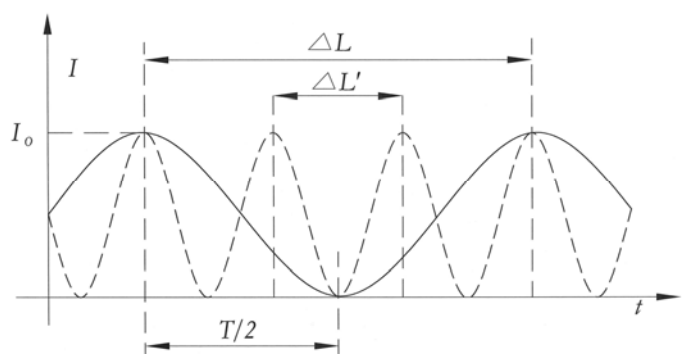

Fig. 9. The "signature" of a 3 to 1 anisotropy ratio between train and embankment systems of inertial motion, extrapolated from Fig. 8, with the revised train speed of C/2. The solid sine wave is moving left; the dotted wave is moving right.

But Fig. 9, to make whole exercise as concrete as is possible at this stage, graphically illustrates the objective differences between the two sinusoidal waves, above, which it might someday be possible to verify. For objectively, as it has been argued here, their relative power levels should vary as shown: at the two positions, left and right, which are each marked by dotted vertical lines extending downward from the opposite ends of ΔL , their respective two power levels are equal and the same. But at the two positions between them, also indicated by dotted vertical lines extending downward from the line labeled $\Delta L'$, they are equal but not the same as the first two.

In an inertial frame of reference that is truly isotropic, such a difference in energy patterns, from one cycle to the next, never would be the case.

Figs. 9 and 8, taken together, also have another key purpose. They also demonstrate a another critical fact: *that the existence of*

two equally isotropic systems in just one physical place, but possessing a relative motion with respect to each other, is both a logical and a physical impossibility.

Such relative motion between two validly isotropic systems, nevertheless, within the vast expanse of nature itself, may indeed be quite possible, despite all the poorly supported theoretical claims of the past, to the contrary. Such a "velocity potential" however, (claimed to be impossible by Michelson, within the Lorentz theory) might be possible given only that the locations are sufficiently distant from one another; for example, quite possibly at the opposite ends of the Earth's solar orbit -- another possibility which may be found in the historical record, but one, if Michelson and Morley in fact had been aware of it, they may have been too timid to bring up.

But this was a possibility which perhaps a mind as great as Maxwell's might considered seriously, for there is no doubt that he was intimately familiar with Newton's *Philosophiae Naturalis Principia Mathematica,* chapter and verse. Also he would have been able to discuss it with his friends in private, without fear of ridicule or the threat of other more serious forms of professional intimidation. After all, it was his own writing about the possibility of measuring a "relative aether wind", in the ninth edition of the *Encyclopedia Britannica*, 1878, that originally had inspired Michelson's experiment [32].

But to revive this old idea would have meant contesting the validity of the god-like Newton's alleged "disproof" of René Descartes' vortex theory of planetary motion [33]. At Trinity College, Cambridge, where Newton's genius had been incubated, and where Maxwell had been a fellow and had won the coveted Smith Prize, this would have been tantamount to treason. But without a shade of doubt it would have taken someone of at least Maxwell's stature, imagination and vision to propose such a monstrous proposition, for realistically there was virtually no credible physical evidence with which to support such a wild conjecture, especially one with such unpleasant French associations. Had a still-living Maxwell been able to time-travel into the 22nd century, then perhaps he might have collected something useful for evidence -- but there was none to be had in the time of Queen Victoria. Even today, supporting such a position would not be easy, even if with our advances in understanding structure of matter over the last century -- especially with quantum mechanics.

Nature's timing concerning exactly when we are permitted to see the various pieces to its puzzles does not necessarily follow a neat serial order; thus, fitting them into a coherent picture is seldom a breeze. This may have been one of the more vexing problems of this type -- since it would have meant invalidating a previously identified "crucial experiment."

But today, why not resolve to treat a matter of such profound significance as a fresh experimental problem which science should attack anew, throwing away all the old preconceptions? Past physics in this subject area, as well as the extensive commentary upon it by historians of physics, philosophers of science, and the ubiquitous science writers, consistently has been unreliable, confusing, and misleading. Prolonged uncertainty in science doubtlessly breeds increasingly desperate suggestions. Nature may abhor a palpable conceptual vacuum in human knowledge almost as much as a physical one. From Michelson's first version of his great experiment to the appearance of special relativity, twenty-three baffling years went by. Einstein may have denied that the experiment was a critical component in his thinking, but there is no record of his ever having complained about the use of his theory to "explain" its result.

6. Conclusion

Following are a list of provisional conclusions about this revision of Einstein's original thought experiment. Whether or not they seem adequately justified must be a matter for individual readers to decide for themselves.

It may be helpful to keep in mind that from studies of double stars and other tests, that it is a well-established fact that the speed of light is independent of the motion of the light source. Specifically, this means that whether the light source for the experiment described here rides with the train, or is fixed on the embankment, or is delivered both ways, makes no difference.

1. On the train, the ratio of ΔL for cycles moving rightward, to ΔL for cycles moving left, is 1 to 3. This anisotropic ratio of one-way light speeds in opposite directions must be thought of as a physical effect that has been caused by the train being put into that particular inertial frame of motion. In principle, through advanced engineering, future experiments conducted which use the design principles described here eventually should be possible. When they are, it should be possible to prove this fact experimentally.
2. For the cycles shown on the lower part of the diagram, those connected to the Kerr cell tests on the embankment, the corresponding ratio for comparison is 1 to 1. Therefore this inertial frame of reference is isotropic. But it should also be kept in mind that what has been described here is merely an idealization, one which is based upon a specific assumption; one certainly should not confuse this with a real embankment or a real train, actually existing on the earth's surface. For the Sagnac effect, plus the Earth's constantly changing orbital speed injects complications that must be taken into consideration [34]. The Earth is not "really" an inertial system. But this is equally true for Einstein's original example, and it is worth thinking about very carefully, to avoid being misled.
3. The only way that physical, logical, and objective sense can be made of Einstein's train example, once its true logical entailments have been extended more fully, is to endorse the position: that, in reality, distant simultaneity must be exactly the same for each of these two inertial frames of reference -- the train and the embankment. Any other treatment leads ultimately to confusion and loss of physicality. On this basis, the role of conventionality in the simultaneity issue can be resolved objectively: its correct component of applicability is "none." And Malament's celebrated uniqueness theorem, derived as it was from the relation of symmetric, causal connectability in Minkowskian space-time, similarly must be judged as having no role to play in understanding the real physical world: for the underlying, Minkowskian, or special relativistic, mathematical context needed for its ontological support no longer can be considered a legitimate platform for scientific work. Without being able to assume the truth of a complete equivalence of all inertial frames, such a format be-

comes a purely mathematical conceit, totally divorced from physical reality. Space and time, once again, must be treated as separate and independent "entities," contra Minkowski's famous pronouncement. Returning to this older position also seems consistent with the great majority of Poincaré's other work before his untimely death. Minkowski re-interpreted Poincaré's original work in much the same fashion as Einstein re-interpreted Lorentz's ideas. (Today, even the term 'Poincaré Group' remains in use, within Minkowskian space, just as the "Lorentz transforms" appear consistently in special relativity). But at this point, it seems appropriate provisionally to return to the original interpretations of both originators, and to put an end to the pseudo-causal role of "space-time."

4. No one cares what "time it is," (*i.e.* in the traditional sense), not at A, A', M, M', B or B'; or anywhere else, for the specific purposes which have been investigated here. Furthermore, never has there been any need for numerically synchronizing any clocks. Einstein's assertion that this was a necessary first step in physics now should be identified simply as an opinion which turned out to be wrong.
5. The by now, familiar effect which motion has on clocks, i.e. slowing them down, and which has been produced by various different physical experiments, now demands a new, fully causal explanation, as many have suggested over the years; in essence following the Lorentzian approach, in principle [35]. But much additional theoretical work will be needed if we are to secure a complete understanding of this issue. After all, Lorentz died in 1928. Initially, however, a reasonable presumption might be that clock slowing would be greater in those inertial systems with a high level of anisotropy. Maximum relative clock speed, on the other hand, correspondingly, might be expected in isotropic inertial systems, perhaps uniformly from one distant system to another distant system, but certainly subject to verification -- if and when this should ever become feasible. Also, this process should not necessarily be expected to produce a so-called "law" which is very much different from the kind of complete, multi-faceted statement presently required to describe sound velocity in air adequately. Above all, a single finding of isotropy in some one, single system must not be linked to the archaic metaphysical Newtonian concept of "absolute rest." To create a scientific basis for such a metaphysically ambitious concept, much more empirical evidence would have to be collected from truly distant places. Any assertions about "absolute rest" lie outside the present range of our scientific competence.
6. No one cares if the train has a different length, measured from A' to B', if at rest with respect to the embankment, versus when the train is in motion, again with respect to the embankment. This existence of this kind of strictly causal effect has no bearing upon the validity and objectivity of this exercise. That the physical train still is able to span the distance from A to B on the embankment is all that is required here. Besides, no physical experiment, thus far, has confirmed this effect. Also, it should no longer be thought of as absolutely required in order to explain the Michelson-Morley experiment. If ultimately this shrinking can be shown to be the case experimentally: *i.e.* entirely outside the physical context of Michelson-Morley, and isomorphic with the already conclusive, experimental observations of slowing clock rates, then rod shrinking also must receive a casual explanation and an appropriate theoretical treatment -- again following the general lead of Lorentz and Poincaré. And just as before, given proof of the reality of such an effect, then systems with isotropic light velocity might be expected to produce the greatest rod length; and rod shrinking would be expected to be progressively more accentuated in highly anisotropic systems.

Let the discussion begin.

References

[1] A. Einstein, **Relativity: The Special and General Theories**, 15th Ed., pp. 25-27 (Crown Publishers, New York, 1961 -- original 1916).

[2] Einstein, *Ibid*, p. 26 (1916).

[3] A. Ungar, "Ether and the one-way speed of light." *American Journal of Physics* **56**: 814 (1988).

[4] Einstein, *Ibid*, p. 26 (1916).

[5] Herman Erlichson, "The Rod Contraction-Clock Retardation Ether Theory and the Special Theory of Relativity", American *Journal of Physics* **41**: 1068-1078 (1973). This paper provides the classic statement of a viable alternative, emphasizing the work of Lorentz and Ives.

[6] Peter Galison, **Einstein's Clocks, Poincaré's Maps: Empires of Time**, (Norton, New York, 2003). For an authoritative example of excess confidence, one which even goes so far as to tout another, similarly misguided, and even more august example, see p. 25.

[7] A. Einstein "On the Electrodynamics of Moving Bodies," *Annalen der Physik* 17 (in **The Principle of Relativity** (Dover, New York, 1952) translated from "Zur Elektrodynamik bewegter Korper," pp. 35-65 (1905). See p. 39. for the "postulate" comment.

[8] A. Einstein, *Ibid*, p. 23 (1916).

[9] A. Einstein, *Ibid*, p. 24 (1916).

[10] A. Einstein, *Ibid*, p. 38 (1905).

[11] http://plato.stanford.edu/entries/spacetime-convensimul/.

[12] http://plato.stanford.edu/entries/spacetime-bebecome/#Spec.

[13] John Winnie, "Special Relativity Without One-Way Velocity Assumptions: Parts I and II", *Philosophy of Science* **37**: 81-99, 223-238 (1970).

[14] David Malament, "Causal Theories of Time and the Conventionality of Simultaneity." *Nôus* **11**: 293-300 (1977).

[15] Wesley C. Salmon, **Space, Time and Motion: a Philosophical Introduction**, 2nd Ed. (University of Minnesota, 1975); "The Philosophical Significance of the One-Way Velocity of Light", *Nôus* **11**: 253-292 (1977).

[16] Hans Reichenbach, **Philosophy of Space and Time** (Dover, New York, 1958).

[17] Salmon, *Ibid*, pp. 113, 126 (1975).

[18] Charles Nissim-Sadat, "Can one measure the one-way speed of light?", *American Journal of Physics* **50**: 533-536 (1981). Another example of 'outside' opposition; Erlickson, *Ibid*, (1973), esp. p. 1076.

[19] A. Einstein, *Ibid*, p. 38 (1905).

[20] Albert Einstein, Leopold Infeld, **The Evolution of Physics; From early concepts to relativity and quanta** (Clarion, New York, 1938). For what might be called a "Karl Rove" example of historiography, but one which may have been written originally by his co-author, rather than by Einstein himself, see pp. 175-176.

[21] E. D. Greaves, An Michel Rodriguez, and J. Ruiz-Camacho, "A one-way speed of light experiment", *American Journal of Physics* **77**: 894-896 (2009).

[22] J. Finkelstein, "One way speed of light?", *American Journal of Physics* **78**: 877 (2009).

[23] Ungar, Ibid, 814 (1988); see also Robert W. Brehme, "On the physical reality of the isotropic speed of light", *American Journal of Physics* **56**: 811-813 (1988).

[24] Einstein and Infeld, *Ibid*, (1938).

[25] Roberto Torretti, **Relativity and Geometry**, p. 87 (Pergamon, New York, 1987).

[26] JinXi Dong, Bo Dong, "A theory on measuring the one-way speed of light and a method of verifying the invariance of light speed", *Physics Essays* **24**, 294-300 (2011).

[27] Dong, *Ibid*, p. 297 (2011).

[28] Dong, *Ibid*, p. 299 (2011).

[29] Adolph Grűnbaum, Wesley Salmon, Bas van Fraassen, and Allan I. Janis, "A Panel Discussion of Simultaneity by Slow Clock Transport in the Special and General Theories of Relativity", *Philosophy of Science* **36**: 1-81 (1969).

[30] Dong, *Ibid*, p. 298 (2011).

[31] Dong, *Ibid*, p. 300 (2011).

[32] Loyd S. Swenson, **The Ethereal Aether: A History of the Michelson-Morley-Miller Aether-Drift Experiments, 1880-1930** (University of Texas Press, Austin and London, 1972). See p. 57, referring to Maxwell's importance to Michelson and his experiment. See also p. 273 for Michelson and Morley's final comments about the impossibility of a velocity potential within the Lorentz theory, taken from their original, 1887 report.

[33] http://www.new-science-theory.com/isaac-newton-principia-descartes.php; http://en.wikipedia.org/wiki/Experimentum_crucis; E. J. Aiton, **The Vortex Theory of Planetary Motions** (Macdonald, London & American Elsevier, New York, 1972).

[34] Howard Hayden, "Is the Velocity of Light Isotropic in the Frame of the Rotating Earth?", *Physics Essays* 4: 361-367 (1991).

[35] Erlichson, *Ibid* (1973); For earlier statements of a research position aimed in this general direction, see also, T. G. Franzel, "Distant Simultaneity and the Bilateral Symmetry of a Rotating Object: An Epistemic Alternative to Newton's Water Bucket Experiment as the Cornerstone in Philosophy of Space and Time, Parts I and II," especially pp. 238-240, *Physics Essays* **1**: 184-208 & 213-243 (1988); also see, T. G. Franzel, "The Strange and Checkered Career of Carrington's Law: A Century and a Half of Solar Modeling," especially pp. 558-559, *Physics Essays* **12**: 531-569 (1999).