the general science journal

Herbert Dingle Was Correct! Part XII

The Dingle-Grünbaum Debate Over The Lorentz-FitzGerald Contraction Hypothesis and The Reality Of The Lorentz-Einstein Length Contraction Effect

By Harry H. Ricker III, Email:

kc3mx@yahoo.com

1.0 Introduction

This paper addresses an exchange of views between Herbert Dingle and Adolf Grünbaum that occurred in The British Journal For The Philosophy Of Science in the early 1960s. The debate took place as an exchange of letters that appeared in the discussions section of the referenced journal. The proximate subject of the exchanges was whether the Lorentz-FitzGerald contraction hypothesis was an ad hoc hypothesis. However, this evolved into a discussion over the interpretation of the Kennedy-Thorndike experiment advanced by Grünbaum, which Dingle rejected, and the "reality" of the Lorentz-Einstein length contraction effect.

In a previous paper of this series, an attack upon Herbert Dingle which appeared in two papers written by Adolf Grunbaum was discussed. There is no evidence that Dingle replied directly to these attacks. That attack involved Dingle's views regarding the reality of the Lorentz-Einstein length contraction effect. However, it is not likely that he was not aware of them. The criticism was published twice, first in 1955 and then again in a revised version of the same paper which appeared in a book on the philosophy of science published in 1960.

One of the main arguments advanced in the two papers written by Grunbaum, was the assertion that, the Lorentz-FitzGerald contraction hypothesis was not ad hoc. This was intended to be a revision of the established dogma of relativistic rhetoric. Here we will use the framework of the discussion between Dingle and Grunbaum as an occasion to investigate the reasons for the different viewpoints, and learn a little about how the history of relativity twists the facts of history to advance the relativity agenda.

2.0 Background

In this section we will investigate the history leading up to the debate between Dingle and Grunbaum, and try to put the issue into perspective.

2.1 The Ad Hoc Lorentz-FitzGerald Contraction Hypothesis

When we investigate the history of relativity physics, we discover that the established dogma goes something like the following very simplified example.

When Michelson discovered that he was unable to measure the velocity of the earth relative to absolute space, FitzGerald proposed that the null result could be accounted for by the hypothesis that the motion of the instrumental apparatus through the ether caused a contraction or shrinking of the apparatus such as to compensate exactly for the null result which was observed. Lorentz took up this idea and turned it into a theory of the ether, which claimed that the required contraction was the result of molecular forces due to motion through the ether. Einstein, however, realized in a brilliant philosophical insight, that the contraction hypothesis, being ad hoc, was not needed at all, and by the employment of

two apparently irreconcilable postulates was able to show how the null result could be explained without recourse to the ether hypothesis, and thereby demonstrated that there was no absolute space or time at all.

Of course this is only a schematic or outline of the story, but versions like it appeared frequently in physics textbooks and books on the theory of relativity. The first question we need to ask is, where did this story come from? One answer is given by Grünbaum. He specifically cites the interpretation given in the book Introduction to Modern Physics by Richtmyer, Kennard, and Lauritsen, 5th edition 1955. First published in 1928, and revised in 1934, 1942, 1947, and finally in 1955, this book was probably one of the most well known American physics textbooks of the era. Grünbaum's particular objection to it was "because it inverts the logical order of Einstein's ideas and badly beclouds their epistemological anchorage."

This writer looked into this question, but was unable to pin down the exact source of this story or interpretation of relativity history. There are however the following facts. The idea that the Lorentz-FitzGerald contraction hypothesis is an ad hoc hypothesis, appears as a common concept in physics books published after the second world war in the early 1950s. The same statement does not appear in the relativity books published in the 1920s. In the few books examined which appeared in the 1930s, this writer identified two textbooks, including the one cited by Grünbaum, which expressed this idea. Thus it appears that the story is a phenomenon which became prominent in the relativity literature in the early 1950s, but its source remains unidentified.

Here we are looking for the exact origin for the concept that the hypothesis was ad hoc. It appears that a different conception of this arose from statements made by Hermann Minkowski in his famous paper of 1908, "Space And Time", which appears in the well known book The Principle Of Relativity. Although he does not call the hypothesis ad hoc, he does say: "This hypothesis sounds extremely fantastical…", and continues by referring to it "simply as a gift from above,---as an accompanying circumstance of the circumstance of motion". This is most likely the source of the epistemological argument that the hypothesis is unsatisfactory for philosophical reasons.

This theme was expressed by Max von Laue who said that "A really experimental decision between the theory of Lorentz and the theory of relativity… is indeed not to be gained, and that the former in spite of this has receded into the background, is chiefly due to the fact, that, close as it comes to the theory of relativity, it still lacks the great simple universal principle, the possession of which lends the theory of relativity…an imposing appearance." What this means is that absent definitive experimental evidence to decide the issue, the choice was made in favor of Einstein because his theory was prettier or more epistemologically satisfactory than Lorentz' contraction hypothesis. The reader who is not asleep, has probably realized that this is a pretty weak criterion for deciding between alternate scientific theories, so we should not be surprised to discover that there were numerous attempts to shore up the reasoning at the foundation of the theory as the years passed. Grünbaum's proposed revision in his 1955 paper was merely another revision in the long chain of revisions that have taken place over the years.

We close this discussion with the surprise discovery that Einstein may be the source of this story. In his second paper published in 1907, he makes the following statement: "It is well known that this contradiction between theory and experiment was formally removed by the postulate of H. A. Lorentz and FitzGerald, according to which moving bodies experience a certain contraction in the direction of their motion. However, this ad hoc postulate seemed to be only an artificial means of saving the theory: Michelson's and Morley's experiment had actually shown that phenomena agree with the principle of relativity even where this was not to be expected from the Lorentz theory." Notice that Einstein is asserting that the primary reason for the null result is given by appeal to the relativity postulate and he does not appeal to the light constancy postulate as the explanation.

The curious aspect of this, is that this statement made by Einstein does not appear to have been repeated in other papers or books written by him. The words ad hoc do not appear in the relativity books of the 1920s, and as noted above only appears frequently in books after 1950. So the question still remains, but is stated this way: Why did the idea that Lorentz' contraction hypothesis was ad hoc gain such popularity after about 1950 when it appeared very infrequently before that date? We will now leave this problem for historians of science to resolve.

2.2 The Michelson-Morley Experiment

For reasons which are lost in the passage of time, the experiments which go by the name of the Michelson-Morley experiment are really not a single experiment but a series of experiments. The most famous, which was conducted by A. A. Michelson at Case Western reserve University included Morley as co-author on the well known paper which appeared in the American Journal of Science in 1887. It is probably the most famous paper in the history of nineteenth century American physics. It took place at a time when American physical practice was the poor second cousin to European physical science. Hence, its well deserved fame. It was the brainchild of Michelson, who had performed a similar experiment in 1881. His purpose was to measure the orbital velocity of the earth in its travels around the sun-- a project that was suggested by James Clerk Maxwell. Michelson's genius was the design of an experiment capable of performing the measurement. But the 1881 experiment measured nothing. There was no indication of any velocity at all. The experiment, which was repeated in 1887, used an improved and much more sensitive apparatus. But the result was the same as obtained in 1881. The orbital velocity of the earth in its motion around the sun was measured to be zero. No motion could be detected at all. This, however, did not precipitate a crisis in physics as some authors suggest it did.

In fact it seems probable that few physicists knew about this experiment or even cared that the result obtained was zero. The problem was in the narrow field of electromagnetic theory, and the result had three different ways that it could be satisfactorily explained. The first was that there was no stagnant ether, as it was sometimes referred to in relativity books. That theory was the theory of Fresnel. It was considered more probable than the theory of Stokes who asserted that the ether was dragged along by the earth in its motion around the sun. This theory, which was the second way the result could be explained, was considered improbable for a number of reasons, based upon experiments. The third way the result could be explained was that proposed by FitzGerald. He didn't propose a theory, but merely pointed out that the result would be compatible with the idea that the motion through the sun centered ether caused a physical contraction of the experimental apparatus so that the contraction effect compensated for the motion through the ether, producing the result that a velocity could not be measured in this manner. This explained why the measured velocity was zero. The purpose was not to save the ether hypothesis but to explain why the resulting measured velocity was zero. This had the effect of saving the appearance of the Fresnel ether theory, as against the Stokes ether theory. In 1904 Lorentz published a detailed theory which attempted to save or preserve the Fresnel ether theory, and which predicted the Lorentz-FitzGerald contraction effect as a result of changed molecular forces due to motion through the Fresnel or sun centered ether. It employed the Lorentz transformation equations for electric and magnetic fields.

The Stokes ether theory was perfectly consistent with the Michelson experiments, because since according to it, the ether was carried along around the sun with the earth in its orbital motion, because the predicted velocity measurement was exactly zero. Hence, the results were consistent with this theory. But, this theory was rejected for reasons which were rather vague and obscure.

In 1905 Einstein published a different theory of the Lorentz transformations for electric and magnetic fields, which relied upon the relativity postulates. He made the famous statement that the "luminiferous ether" would prove to be "superfluous", because theory which he developed did not require an "absolutely stationary space". This has been interpreted as a denial of the reality of the ether and the denial of an absolute space. But the statement itself is not sufficiently clear to infer exactly what it was that he was saying at the time. This was interpreted in all kinds of ways to support the view that he had abolished both the ether and absolute space and time. Later Einstein backtracked on the denial of the ether, but the previous interpretation remained forever linked to his name.

2.3 Einstein's Reinterpretation Of The Michelson-Morley Experiment

It is a well known fact that Einstein did not mention or cite the Michelson-Morley experiment in his first, the most famous and well known, relativity paper of 1905. This fact has been the source of considerable controversy, because he later claimed he did not know of it at the time, but based his theory on different principles. We saw above that he did find a reason to refer to the Michelson-Morley experiment in his 1907 paper. He makes use of it to justify his formation of the principle of relativity. It is as if he is

formulating this principle by induction from the null result of the experiment. He says: "It seemed therefore as if Lorentz's theory should be abandoned and replaced by a theory whose foundations correspond to the principle of relativity, because such a theory would readily predict the negative result of the Michelson-Morley experiment." At this point we would expect that a proof of this prediction would be forthcoming, but was never produced. Einstein expects that this be accepted on faith, and many experts did do so. However, the failure to actually prove this statement was a great failure of the theory as we shall see.

In the very next paragraph, Einstein gives the key to his proposed solution "…a sharpened conception of time was all that was needed to overcome the difficulty discussed." Hence we are told that time is the solution and not a contraction of space as implied by the Lorentz's solution based upon the contraction hypothesis. Einstein then dispenses with the ether as follows: "Only the conception of a luminiferous ether as the carrier of the electric and magnetic forces does not fit into the theory described here; for electromagnetic forces appear here not as states of some substance, but rather as independently existing things that are similar to ponderable matter and share with it the feature of inertia." Later in the paper, he justifies the postulate of relativity in this way: "We now make the simplest possible assumption, which is also suggested by the Michelson and Morley experiment: *The physical laws are independent of the state of motion of the reference system, at least if the system is not accelerated*." The light postulate is defined this way: "We now assume *that the clocks can be adjusted in such a way that the propagation velocity of every light ray in vacuum---measured by means of these clocks---becomes everywhere equal to a universal constant c*, provided that the coordinate system is not accelerated." This sounds very much like the ad hoc contraction hypothesis of Lorentz. We can now understand why the ad hoc nature of the Lorentz contraction is not emphasized too much in the early years of the theory, because it is clear that the fundamental assumption is really being pulled out of the air and seems just as "fantastical" and "a gift from above" as the Lorentz hypothesis.

2.4 The Philosophical Difference Between Lorentz-Michelson and Einstein Regarding The Existence Of Ether

In his 1910 paper, Einstein makes clear the philosophical differences that contrast his use of The Principle Of Relativity, with the research programs of Michelson and Lorentz. This section will try to make clear that the difference is rooted in a contrast of scientific method and approach. The research program of Michelson was purely experimental. His original objective was to measure the velocity of the earth in its orbit around the sun by using the ether wind effect. But when he obtained the unexpected result that the velocity was zero, he modified his research goals. He then sought to ascertain if the ether theory of Stokes was the correct ether theory as opposed to the Fresnel theory. Lorentz on the other hand was a theorist who sought to construct an electromagnetic theory upon the most current empirical and theoretical knowledge. Michelson's results, combined with FitzGerald's contraction idea, suggested to him how the Fresnel theory could be modified to comply with the most current empirical results. Thus Lorentz's procedure as a theory builder was constructive. He built upon empirical facts, as he saw them, which were established upon the solid foundation of theoretical models. For him it was natural to incorporate the contraction hypothesis into his theory, and the result was a success.

Einstein in contrast was a philosophical innovator in science---which could be good or bad. He did not build upon painstakingly built up knowledge, but instead relied upon insight obtained from intuition of physical laws as his guide to new physical knowledge. Lorentz's approach was in the tradition of Faraday and Maxwell, while Einstein's was more in the tradition of Newton's axiomatic method. Lorentz was closer in physical tradition to the experimental scientist, while Einstein was closer to the tradition of philosopher scientist. Hence, we can see the great epistemological appeal of Einstein's theory to a philosopher scientist, and its lack of appeal to the experimenter. But in physics, it is the theorists and philosophers who decide upon theories.

In his 1907 paper, Einstein tries to establish that the Michelson-Morley experiment provides the empirical warrant for a belief in the validity of the Principle Of Relativity. He denigrates the alternative contraction hypothesis of FitzGerald and Lorentz by calling it ad hoc. However, when he introduces the light velocity postulate he bases it upon the relativity of time, in a manner which is just as ad hoc. In the 1910 paper, the philosophical part of his argument is given a much larger and more prominent role, than in his previous papers. He begins with a long discussion of ether theory. To this writer, it seems that much of this was developed in Einstein's mind only after he had completed the electrodynamics

paper in 1905, which as we know was a theory of electrodynamics of moving bodies and not really a Theory Of Relativity. That theory only begins to become a clear reality in the 1907 and in the 1910 papers, which give pride of place to the Principle of Relativity, but not to the light principle. (In these papers the titles draw attention to the Principle Of Relativity as fundamental because this phrase appears in the title.)

In the 1910 paper, a long discussion of the ether and its problems forms the introduction and focus of the paper. This is followed by a discussion of the optics of moving bodies and the ether. The third section discusses the Michelson-Morley experiment, and there Einstein says of the expected result: "However, nothing of the kind was observed, and as a result the foundation of Lorentz's theory seemed extremely shaky. To save the theory, Lorentz and FitzGerald resorted to a strange hypothesis: they assumed that each body in motion with respect to the ether contracts in the direction of motion…The hypothesis succeeded in effect in eliminating the disagreement between theory and experiment. But the theory did not offer an intellectually very satisfying whole. It was based upon the existence of an ether that one had to conceive as being in motion with respect to the earth, with the consequences of this motion forever unverifiable by experiment; this peculiarity could only be explained by introducing *a priori* implausible hypotheses into the theory. Could one really believe that, by a curious accident, the laws of nature present themselves to us in such a highly unusual way that none of them allows us to know about the fast motion of our planet through the ether? Is it not more plausible to assume that some wrong or defective argument had led us to this impasse?" There is here a polemical argument, and not a scientific one based upon facts. But, it had a certain appeal. Unfortunately it is based upon a distortion of the facts, which are twisted to make the argument seem inevitably correct. It is self serving science marketing, to promote his theory, posing as philosophy.

The really important argument follows this. It is a reprise of his argument, alluded to in his 1905 paper, which was never explained. He argues that the ether theory can not explain the generation of current in a relatively moving wire by a magnet. This argument is essentially correct. There are however some very big problems. The upshot is that there is a severe difficulty in electromagnetic theory on this particular point. The modern relativity theory, which is not based upon the ether, does not explain this problem any more successfully without difficulties. The main problem being the peculiar exception of unipolar induction, which refuses to behave in the modern electromagnetic theory, which is not based on ether, in much the same way that the theory based on the ether also failed. So there is really not a problem relating to the ether as much as to some other aspect of the theory. But Einstein saw this problem as a reason to reject the ether.

The anti-Lorentz propaganda continues through section 4, where Einstein says that: "Lorentz's theory contradicts the purely mechanical models to which physicists hoped to reduce all the phenomena of the universe. For while mechanics in effect admits of no absolute motion, but only relative motions…there is a particular state in Lorentz's theory that corresponds physically to the state of *absolute rest*…Thus the theory of Lorentz, based on the ether hypothesis, does not admit to the principle of relativity…it is so much more improper to accept a theory that is not consistent with the principle of relativity, the more so because this principle has not been contradicted by a single experimental fact." In section 5, Einstein tells us that we can save Lorentz's theory despite the contradiction by adopting a new definition of time which makes light velocity the same in all relativity moving frames. This saves the compatibility of Lorentz's theory with the principle of relativity and provides a way to escape the apparent inconsistencies. But it is not really clear whether we are to keep the ether or not in Einstein's proposed solution of the contradiction.

In Einstein's 1911 paper we encounter for the first time "The Theory Of Relativity", which is the title of this paper. It deals primarily with what we today consider the special theory of relativity without the electodynamical part. It is a propaganda piece, or less perjoratively, primarily an advertisement or science marketing paper to advance the agenda of the newly christened Theory Of Relativity. It lacks mathematical details, gives the conclusions, and justifies why they are demanded by the physical facts. We see from it, that Einstein's emphasis has shifted from the context of discovery, as in his 1905 and 1907 papers, to the context of justification which is the primary aim in his 1910 and 1911 papers.

Einstein says: "The one basic pillar which the theory designated as the "theory of relativity" rests is the so-called principle of relativity…the laws of nature are independent of the translational motion of the reference system…I shall now analyze how experience has led physicists to the formulation of laws

which contradict this principle…the theory …below is incompatible with the ether hypothesis…In that sense, Lorentz's basic concept of the stationary ether does not satisfy the principle of relativity…" He goes on from here to explain how Lorentz's theory can be saved, by the redefinition of time which makes light velocity the same in all inertial reference frames. Hence, he concludes that although Lorentz's theory is false, because it produces a contradiction with the principle of relativity, by a modification of our conception of time, it can be salvaged. This is an important and often overlooked point. What this means is that Lorentz's ether theory is an integral part of The Theory Of Relativity, because it is that theory which provides the basis of justification for the Theory Of Relativity.

This leads to the unfortunate consequence that it is not clear in Einstein's papers whether the ether stays or goes. If Lorentz's theory can be saved, then the ether can as well. But we often hear that Einstein asserted that the ether was false, and didn't exist. But, in fact, there doesn't seem to be a clear statement on this point. At least not one that this writer could find in Einstein's early papers.

All of this is compounded by what Einstein said in his 1920 paper "Ether and the Theory of Relativity". There Einstein says: "More careful reflection teaches us, however, that the special theory of relativity does not compel us to deny ether. We may assume existence of an ether; only we must give up ascribing a definite state of motion to it…" On this note, we will leave off the discussion of Einstein's views on the ether and conclude that we can not decide upon the existence of an ether based upon what Einstein has to say about it.

2.5 The Kennedy-Thorndike Experiment

During the early years of the 1930s, Roy J. Kennedy and Edward M. Thorndike performed an experiment that is described in a paper titled "Experimental Establishment of the Relativity of Time" in the Physical Review, Vol. 42, Nov. 1932, p. 400. The grandiose title obscures the claimed real accomplishment of the experiment, which was verification of the Michelson-Morley experiment with the added feature that it was designed to preclude the Lorentz-FitzGerald contraction effect in the experimental design. Another feature of the experiment, which is probably of much greater importance, was that it was based on obtaining photographic measurements of fringe shifts over time and then reducing these to statistical analysis. This permitted definitive long and short term measurements of fringe shifts in a quantitative manner. The earlier Michelson-Morley results were not photographically recorded and did not take place over a long period of time. Hence, the Kennedy-Thorndike experiment permitted an analysis of a daily and a long term, or yearly, fringe shift effect.

Unfortunately, the results were not as definitive as one would have liked. The results were investigated with the objective of confirming relativity and disconfirming results were discounted as experimental errors. Hence, there is some discomfort in accepting the conclusions as definitive, after one carefully reads the paper. There are as many unanswered questions as before the experiment took place. But the central object had been fulfilled. That was to confirm relativity and any disconfirming results were left out of the research. Hence, we do not have a definitive answer regarding the reason for a diurnal fringe shift. There were also several provisos. One of them was the assumption that the frequency of the light source is not affected by the time dilation effect due to motion of the instrumental apparatus. One is also left with the uncomfortable feeling that the relativity of time was not established experimentally, because how this was done was not exactly clear. In fact, this fundamental claim was not really made clear in terms of what exactly was meant by the phrase "the relativity of time". As we know from logical positivism, all observational sentences must have a clearly defined meaning in order to not be declared meaningless.

In the following, we quote from the paper by Kennedy and Thorndike in order to understand their experimental design. "Among the several classical experiments …there appears to be none in which any question as to the nature of time is involved…the Michelson-Gale experiment gives a positive result, which is consistent with the concepts of either relative time or absolute time…it seems that the only experiment…that permits of definite interpretation is that of Michelson and Morley; and the null result of this experiment is completely explained if we suppose that space dimensions in the direction of motion are contracted by an amount depending upon a suitable function of frequency…no question as to time is raised. Hence although such experiments have suggested the relativity theory they do no form a sufficient basis for the logical derivation of it." Here we see where Grünbaum obtained the idea for his papers on the logical foundation of relativity. The basic problem with the thesis presented is that it is

never defined what is meant by relative and absolute time, and how the difference between these concepts applies to the proposed experiment. Perhaps this becomes clear later.

Continuing from the paper: "It appears, then, that the theory has needed confirmation, particularly in its most revolutionary aspect; i.e., its denial of a significance for absolute time. Such confirmation has been obtained in the work reported in this paper…" Then there is stated the essence of the method but it is not really very specific: "…by combining our results with those of the Michelson-Morley experiment, we derive the Lorentz-Einstein transformations which are well known to embrace the whole theory."

"The principle on which the experiment is based…light is split at a half reflecting surface…which after traversing two paths of different lengths…the relative phases of the superposed beams will depend upon the velocity of the apparatus unless the frequency of the light depends upon the velocity in the way required by relativity." This is the essence of the experiment, and an understanding of this statement is required to understand the debate between Grünbaum and Dingle, because Grünbaum interprets the experiment in a manner different from this statement. Here the underlined part is the key to the debate, and it was put in by this writer for emphasis.

"The theory of this experiment requires the following two assumptions: (a) There exists at least one coordinate system in which Huygens principle is valid and the velocity of light is the same in all directions…(b) the Michelson-Morley experiment indicates that a system moving …has dimensions in the direction of motion contracted…while dimensions perpendicular…are unchanged." Assumption (a) assumes the existence of an external ether rest frame, but does not preclude a relativistic space-time, while assumption (b) is the Lorentz-FitzGerald contraction. Hence the experiment assumes the validity of the contraction effect. Later we discover why.

After a long theoretical discussion filled with equations and obscure reasoning, they say: "This proof is essentially that of Lorentz extended by the inclusion of the contraction hypothesis…Furthermore, it will be shown later that insofar as the atom is to be regarded as a clock, the Lorentz-Einstein transformations can be derived from this relationship and assumption (b). If, on the other hand, [there is no change in frequency due to time dilation with velocity] these transformations do not apply and it turns out that there exists but one system S' satisfying assumption (a); this unique system would be the absolute reference frame postulated in the classical ether theory." Hence the demonstration depends upon the truth of the Lorentz-FitzGerald contraction as stated in assumption (b). But as we will see, most relativists, including Grünbaum, interpret the Kennedy-Thorndike experiment as demonstrating that there is no Lorentz-FitzGerald contraction, and this of course invalidates assumption (b) which then means that the relativity of time can not be established as Kennedy and Thorndike claimed. What the experiment is designed to do is to demonstrate the time dilation formula in terms of a frequency shift. But this could be detected as a fringe shift unless there was a Lorentz-FitzGerald contraction to compensate for the frequency shift and produce a null fringe shift in the measurement result.

The paper then shifts to a description of the experimental apparatus and the conditions of the experiment. Kennedy and Thorndike claim that the null result establishes the claim that the time dilation effect is experimentally demonstrated and is therefore verified. Hence the resulting claim was that the relativity of time was experimentally established. This claim was made despite the fact that the result was not a null. There was a diurnal effect measured, which apparently meant that the rotation of the earth was detected. This positive result nullifies the claim that the relativity of time was established. Now as noted by Kennedy and Thorndike in the above quote, the fact that there is not a null result establishes that there is an absolute rest frame. Thus, it is clearly established that the earth is at rest relative to its inertial coordinate system in its motion around the sun, and that it is rotating relative to this rest frame. Hence the Stokes ether hypothesis is established as true. But this was not the way that relativists interpreted the results.

2.6 Textbook Interpretations Of The Kennedy-Thorndike Experiment

Before leaving the topic of the Kennedy-Thorndike experiment, we will investigate the different textbook interpretations that have led to an erroneous re-interpretation of it. The main purpose will be to ascertain the source of the erroneous idea that the purpose was to disprove the Lorentz-FitzGerald contraction effect. As we have seen, the existence of this effect was necessary to prove that the null

result demonstrated the existence of the time dilation effect.

This writer conducted a brief survey of his personal library. While many general physics books mentioned the Michelson-Morley experiment, none of these mentioned the Kennedy-Thorndike experiment. Out of books devoted to the subject of special relativity, again, not all of those citing the Michelson-Morley experiment cited the Kennedy-Thorndike experiment. None cited the Kennedy-Thorndike without citing the Michelson-Morley experiment. The books mentioned below, were the only ones to address the Kennedy-Thorndike experiment. These books represent only about ten percent of the writers books on special relativity. It seems that the Kennedy-Thorndike experiment does not figure as a highly important part of the special theory of relativity. (The writer recognizes that this survey is probably biased because he prefers to purchase older relativity books that were published prior to WWII.)

The following discussion is taken from Relativity, Thermodynamics, and Cosmology by Richard C. Tolman, published in 1934. Tolman says: "We can now put it [the Michelson-Morley experiment] in second place as a part of the direct verification of our postulate, an experiment devised by Kennedy, which on the basis of a fixed ether and a real Lorentz-FitzGerald contraction should still lead to a detection of the motion of the earth through that ether. The apparatus for that experiment consists of a Michelson interferometer with the two arms as unequal in length as feasible, so that the two beams which recombine to give interference fringes have a considerable difference in the time required to pass from the source to the point of recombination. Assuming a fixed ether, but allowing for the Lorentz-FitzGerald contraction associated with the motion through this medium, analysis then shows that the difference should depend in a very simple way on the difference in length of the two arms and on the velocity of the apparatus through the ether. Hence, provided the period of the light source does not itself depend on this velocity, we should expect a shift in the fringe pattern to accompany the diurnal changes in the velocity of the apparatus through the ether produced by the earths revolution [sic, rotation] on its axis, and the annual changes produced by its rotation [sic, revolution] in its orbit. The experiment was of course a very difficult one to perform, but the final results of Kennedy and Thorndike have satisfactorily demonstrated a null effect to the order of the experimental error, which corresponds to a velocity of only about + or - 10 km. per sec."

Surprisingly, the conclusion that Tolman places before the reader is quite different from that sanctioned by Kennedy and Thorndike in their paper. "…the two tests devised by Michelson and Kennedy are the most important and the most simply related to the ideas as to space and time which have been embodied in the special theory of relativity. To account for these two experiments on the basis of a fixed ether it would be necessary to introduce ingenious assumptions as to a change in length or FitzGerald contraction just sufficient to give a null effect in the Michelson experiment, and as to a change in period or time dilation just sufficient to give a null effect in the Kennedy experiment---all to the end of retaining a fixed ether so devilishly constructed that its existence could never be detected. In the theory of relativity however, we proceed at the start from the basis that absolute velocity can have no significance and hence find nothing to trouble us in the result of these experiments" Hence in the interpretation of the experiment given by Tolman, which is the one adopted by Grünbaum, the claimed null result of the Kennedy-Thorndike experiment is taken as warrant for the conclusion that there is no ether, and hence in the experimental result the conclusion follows that there can be no Lorentz-FitzGerald contraction. But there can also be no time dilation effect as well, because no fringe shift has detected.

G. J. Whitrow in his book The Natural Philosophy Of Time, first published in 1961, but here quoted from the second edition of 1980, makes the point very clear: "An important experiment was performed by Kennedy and Thorndike (1932) to discriminate between the older view that the FitzGerald contraction is a real effect and Einstein's view that it is only apparent. Their experiment was a modification of the Michelson-Morley experiment with arms which were unequal, although sufficiently close to each other for good interference fringes to be observed. Allowing for the FitzGerald contraction, but assuming the existence of a luminiferous ether, the time difference for the transmission of light along two arms should be a function of the diurnally and annually varying velocity of the apparatus. The observed absence of any such effect was a powerful empirical argument for Einstein's contention that the velocity of light is the same for different observers in motion relative to each other." To fix the problem that time dilation was not proved, Whitrow says: "Nevertheless, there was no direct experimental evidence in support of the time dilation effect until 1938, when Ives and Stillwell (1938,1941) confirmed formula

(5.36)…" Here the cited formula does not correctly give the time dilation as observed by Ives and Stillwell, but that is a minor point. The point is that it is the standard time dilation formula. (The formula cited when transformed into a frequency gives a result that indicates that the frequency of the moving source is increased. The correct result, obtained by Ives and Stillwell, is that the frequency is decreased as discussed in Kennedy and Thorndike's paper.)

In his book Special Relativity, second edition of 1968, A. P. French has the following to say: "…the arms of the interferometer were made of different lengths…No fringe shifts associated with either the diurnal or the seasonal changes in the motion of the laboratory were found. If we interpret the Michelson-Morley experiment as we have done just above, then the null result of the Kennedy-Thorndike experiment can be construed as evidence that the time for light to travel…in the longer arm is the same in reference frames having quite different velocities. (…if the [Lorentz] contraction hypothesis were adopted as an explanation of the Michelson-Morley result, it would not explain the Kennedy-Thorndike experiment…)" This book was the writers main source for the information on the Kennedy-Thorndike experiment prior to the investigation reported here. Note that it erroneously claims there is no diurnal effect, and that regarding the contraction effect it asserts a claim that contradicts what Kennedy and Thorndike claim. They assert that it proves the relativity of time, i.e., the time dilation effect.

We will conclude this section with two correct but not exactly clear statements of the result of the Kennedy-Thorndike experiment. The first comes from L. Marder's book Time And The Space-Traveller , 1971. "These workers employed an interferometer with unequal arms, and made observations to see whether there was any change in the interference pattern. There was none. Their result could not be explained on the basis of contraction of the apparatus due to motion through the ether, and was concerned with the relativity of time rather than length." The second comes from Lawrence Sklar's book Space, Time, and Spacetime, 1977 paperback edition. In the caption to Figure 25 he says; "This result cannot be explained away by "length contraction" alone, but requires the "slowing down of clocks when in motion with respect to the ether" as well." This last quotation, seems to be the only correct report of the results that this writer was able to find.

2.7 Background Summary

Einstein is the source of the ad hoc charge against Lorentz. However, he does not claim, at least in his early papers, to have refuted absolute time or absolute space as some books assert. He did not claim to have proved that there was no ether, and his theory does not disprove it. The Kennedy-Thorndike experiment does not prove that there is no ether as some books imply, based on an erroneous interpretation not sanctioned by the authors of the paper. It requires an ether to justify the derivation of the Einstein-Lorentz equations. Without an ether there does not seem to be any justification for the time dilation claim, which has been experimentally established. Since time dilation and Lorentz contraction are derived from the same theory using the same assumptions, it appears that the claim that the Kennedy-Thorndike experiment disproves the contraction effect is a bit premature. Hence it is clear that some of the claims attributed, to the Kennedy-Thorndike experiment as definitely proved, may not be correct.

3.0 Karl Popper's Role In The Debate

The proximate cause of the debate between Grünbaum and Dingle is a statement which appears in section 20, Methodological Rules, of Karl Popper's famous book on the philosophy of science The Logic Of Scientific Discovery, originally published in German in Vienna in 1934, and which first appeared in an English edition in 1959. It was the appearance of the English edition which prompted the attack by Grünbaum discussed here.

The reader may wonder, as did this writer, if Popper's comment appears in the 1934 edition as well as the English edition. If it appears in the 1934 edition then it could have been counted as one of the few instances of an ad hoc criticism of the Lorentz-FitzGerald contraction hypothesis that appeared in that time period. However this could not be verified, so it has not been counted in this way.

The controversy was initiated by a comment published by Grunbaum in The British Journal for the Philosophy of Science (BJPS) aimed at Popper's discussion, in which Grunbaum stated that Popper's views were "wholly incorrect".

3.1 Karl Popper's Methodological Rules

In section 20, Popper lays down some rules. "In order to formulate methodological rules which prevent the adoption of conventionalist stratagems so as to meet each with the appropriate anti-conventionalist counter move". His explanation is given in a quotation: "A nice adaptation of conditions will make any hypothesis agree with the phenomena. This will please the imagination but does not advance our knowledge". One of the rules is to require auxiliary or ad hoc hypotheses to be acceptable only if their introduction does not diminish the degree of falsifiability or testability of the system in question. If the falsifiability is increased, then the auxiliary hypothesis is acceptable.

He then gives an example of an acceptable ad hoc hypothesis and an example of an unacceptable one. The unacceptable one he describes as follows: "An example of an unacceptable auxiliary hypothesis would be the contraction hypothesis of Fitzgerald and Lorentz which had no falsifiable consequences but merely served to restore the agreement between theory and experiment--mainly the findings of Michelson and Morley. An advance was here achieved only by the theory of relativity which predicted new consequences, new physical effects, and thereby opened up new possibilities for testing, and for falsifying, the theory."

It is clear that the last statement is needed to forestall the very obvious problem that both of Einstein's "postulates", which are really hypotheses but with different names, are really just auxiliary hypotheses, and they have the rather nasty character of decreasing the falsifiability of the theory. In fact they are more objectionable by Popper's rule than was the original single simple hypothesis of FitzGerald and Lorentz. In Einstein's system two ad hoc hypotheses are involved, and if one is falsified, the other can still be invoked to protect the theory from falsification. So the problem of falsification is twice as great. This is one of the big advantages of the theory that makes it so difficult to disprove, and on the other hand becomes the source of many of the so called misconceptions of relativity. Since neither of the two postulates is falsifiable, then it is obvious that the theory must be accepted, because it can never be disproved, or rejected because it is incapable of falsification. As we see from history, the first alternative is what happened.

I think it should be noted at this point, that Popper is merely expounding his idea concerning what is an acceptable auxiliary hypothesis. Not all philosophers of science agree that auxiliary hypotheses are to be seen as bad, or unacceptable. Paul Feyerabend argues that ad hoc type hypotheses are necessary for the advancement of science and does not agree that they are bad. Popper would probably argue in opposition to the above, that the auxiliary hypotheses in the theory of relativity are acceptable and not bad because they increase our knowledge, as demonstrated by the results of application of the theory. So we see that philosophers of science have what is called a "demarcation problem". This is the establishment of a rule to decide which hypotheses are good and which are bad. As it turns out, the judgment can only be made long after the theory has been tried out for a sufficiently long time, before it can be decided if the hypotheses are really good or bad. In which case the argument over whether the hypothesis was ad hoc or not is irrelevasnt.

It is clear that Grünbaum's viewpoint is that the term ad hoc is to be applied in a pejorative manner, which implies that an ad hoc hypothesis is unacceptable. He is not making the argument that the Lorentz FitzGerald contraction hypothesis is acceptable, he is asserting that of itself the hypothesis is not strictly speaking sufficiently unfalsifiable to regard the hypothesis as false, but that, contrary to the accepted mythology, the falsity of the hypothesis having been demonstrated empirically, shows that it was not ad hoc at all. The reader needs to understand this point. Grünbaum's argument is to bring the Kennedy-Thorndike experiment to the level of a foundational empirical result. To do this, he points out that since it falsifies the Lorentz-FitzGerald contraction effect, then this hypothesis was not after all an unacceptable ad hoc auxiliary hypothesis. Hence the ad hoc argument should be dispensed with, because it no longer served a useful purpose.

This was bound to cause confusion. If one viewed this as an historical claim, it was certainly false, because the accusation of ad hoc-ness was used, as we have seen, by Einstein to establish the

acceptability of the belief that there was no stagnant Fresnel ether. On the other hand, in a non-historical context, the ad hoc accusation argument no longer had any value as a proof of the non-existence of the stagnant Fresnel ether, because now there existed, it could be claimed, experimental proof that the hypothesis was false.

3.2 Karl Popper's Retraction

In the same issue of the journal in which Grünbaum's criticism appeared, and immediately following it, Popper's response appeared. In his response, Popper thanked Grünbaum and agreed with Grünbaum's conclusions. However, Popper used this to reinforce his argument that there are degrees of ad hoc-ness. Evidently Popper only accepted Grunbaum's criticism as applied to the particular case of the Lorentz-Contraction hypothesis, which Grunbaum criticized.

4.0 Grünbaum's Thesis

Grünbaum's thesis was that the Kennedy-Thorndike experiment and not the Michelson-Morley experiment is the proper empirical foundation for the special theory of relativity. He argues that the ad hoc argument advanced by Einstein is not the proper logical way to demonstrate that the ether or--what amounts to the same thing--absolute space, does not exist. This argument was the same as given previously in his two papers with the title "Logical And Philosophical Foundations Of The Special Theory Of Relativity" published in 1955 and 1960. These two papers were discussed in detail in a previous paper in this series. The reader is referred to them for a more complete discussion of Grünbaum's thesis that the foundations of relativity needed revision.

This writer believes that Grünbaum was not aware that Einstein was the source of the ad hoc argument because he writes in his commentary critical of Popper: "The charge of being ad hoc leveled here by Professor Popper is *wholly incorrect* but has persisted in the literature on the philosophy of science for the past half century. I therefore wish to give a refutation of the thesis of non-falsifiability on the basis of a comparison of the reasoning underlying the Kennedy-Thorndike experiment with the design of the Michelson-Morley experiment." This shows that he did not know the source of the argument and the implication that he was undercutting Einstein's argument, which had successfully led to the acceptance of the special theory. Thus we will proceed using the assumption that Grünbaum was unaware that his argument was against the thesis advanced Einstein. This fact will help to explain the resistance to his revisionist thesis.

4.1 The Kennedy-Thorndike Versus Michelson-Morley Experiments

Grünbaum's argument is the following. If a stagnant ether exists as hypothesized by Fresnel, then supposing the prediction of Lorentz's theory which asserts a Lorentz-FitzGerald contraction of the rigid arms of the experimental instruments, a null result is to be expected for the Michelson-Morley experiment but a positive result is predicted for the Kennedy-Thorndike experiment. Hence by this line of reasoning, the experimental proof that there is no ether, or what is often considered to be the same thing, there is no absolute space, follows from the Kennedy-Thorndike null result and not the claim that the Lorentz-FitzGerald contraction is an unacceptable ad hoc type hypothesis.

The problem with this argument is that the concept that there is no ether had already been accepted as a valid result prior to the Kennedy-Thorndike experiment, and therefore its result, rather than being definitive in disproving the ether, was merely a confirmatory proof of what was already accepted as true. Furthermore, there was a problem. Prior to the Kennedy-Thorndike experiment, the special theory of relativity provided an explanation of the Lorentz-FitzGerald contraction and Lorentz-Larmor time dilation effects as part of its truth claims. These were seen to explain the negative result of the Michelson-Morley experiment. However, with the new interpretation required by the Kennedy-Thorndike experiment, these truth claims of the special theory of relativity had no experimental basis. Grünbaum however, fixed part of this difficulty by using the argument that the Ives-Stillwell experiment of 1938 and the disintegration of mesons experimentally demonstrated the time dilation effect.

The result was not a consistent interpretation, but produced inconsistencies. This can be understood as follows. Grünbaum argued that the Kennedy-Thorndike experiment acted as a "light clock" and demonstrated that the round trip "light time" was the same in all inertial frames--a confirmation of the claim that the proper time is the same in all inertial frames. But this leads us back to the clock paradox and the paradox of the twins, since the Ives-Stillwell and meson disintegration experiments showed that clocks kept different times in different inertial frames, while the Kennedy-Thorndike experiment showed that they were the same. Hence two contradictory interpretations could be inferred from the two different experimental results. What the Kennedy-Thorndike experiment showed was that this contradiction was real, while in the Michelson-Morley experiment the contradiction could be explained away by attributing the failure to observe a time dilation effect to the compensating Lorentz contraction effect.

There is also the problem that neither the Michelson-Morley or the Kennedy-Thorndike experiments actually disprove the existence of an ether or a light propagation medium. What they demonstrate is the non-existence of the sun centered Fresnel stagnant ether, but have nothing to say regarding the non-existence of the earth centered Stokes ether. In fact they provide evidence in favor of an earth centered ether or light medium. The fact is that the earth centered light medium was rejected by Einstein based on flimsy arguments and no definitive experiments. Experiments to definitively rule out the earth centered light medium have been proposed but rejected on the grounds that the existence of the ether was definitively disproved by the Michelson-Morley and Kennedy-Thorndike experiments, but as we have learned they can not do this.

5.0 The Controversy Between Dingle And Grünbaum

This section discusses the exchange of comments between Herbert Dingle and A. Grunbaum. It is provoked by the fact that Dingle rejects Grunbaum's arguments against Popper.

5.1 Dingle's Comment Provokes Controversy

This section discusses the modest comment written by Herbert Dingle which provoked a very strong rebuke from Grünbaum. Dingle pointed out that in view of Popper's criterion, the Lorentz-FitzGerald contraction hypothesis was ad hoc at the time it was advanced. Dingle says: "The hypothesis was certainly ad hoc, for the *realization* of its falsifiability came very much later…" Here it appears he means that it wasn't understood how it could be falsified until the Kennedy-Thorndike experiment was designed, and so the hypothesis at the time it was advanced was ad hoc. After some detailed historical discussion, based on Lorentz's paper of 1892, he repeats this in stronger terms: "There could scarcely be a clearer case of an ad hoc hypothesis." He then presents a quotation from Lorentz paper of 1892 which indicated that Lorentz was aware of the difficulty of falsifying his hypothesis, and concluded that "So the only possibility of falsifying the hypothesis that he (Lorentz) could imagine was a repetition of the experiment that generated it". This ends Dingle's historical comments. Here his point is that in Lorentz's 1892 paper the hypothesis was ad hoc.

Dingle then shifted to a discussion of contemporary issues concerning "…the present state of the question." This is followed by a discussion of Lorentz's ideas that lead to the Lorentz transformation equations obtained in 1903. He points out that now in Lorentz's view the hypothesis was not ad hoc. Dingle says regarding Lorentz's 1903 paper: "The "contraction" then ceased to be an *ad hoc* hypothesis, and became falsifiable…". He then discusses Einstein's theory and asserts that both of Einstein's hypotheses are not ad hoc because they are falsifiable: "Both these assumptions are falsifiable, though in different senses." This then leads to a discussion of how Einstein's two postulates could be experimentally verified. He says: "The first would be falsified if a physical effect were found that would distinguish which of two relatively moving bodies could more properly be called the moving one, and it can never be proved that no such effect is possible". For the falsifiability of the second postulate he proposed an "experiment to compare the times of arrival of pulses of light, proceeding from bodies in relative motion but emitting at th same time point, at a distant point along the line of motion." Dingle then closes with a plea to perform this experiment. "It is highly desirable to test, if possible, this basic assumption of existing physical theory."

Before proceeding to Grunbaum's rejoinder, we will examine what points Dingle was trying to make. First, he was asserting that on an historical basis, Lorentz's original contraction hypothesis of 1892, was ad hoc in character. However, in his paper of 1903, this ad hoc character was removed and a different physical hypothesis for the contraction was advanced that could be falsified. Following this, Dingle now discusses the falsifiability of Einstein's two postulates. He notes that there could be ways to falsify both of them. This part is very important because Dingle tries to point out and make clear, the path toward direct experimental testing of Einstein's two postulates. This is where, it appears, he touched a sensitive issue. The reader should fix this point firmly in his mind. What Dingle is advocating is that direct experimental tests of Einstein's fundamental postulates need to be performed. It is clear that this is the main reason for writing the commentary. It was not to refute Grünbaum's claims regarding Lorentz's hypothesis.

Finally, it should also be noticed that Dingle doesn't attach much negative implication to the conception of an ad hoc hypothesis, so he doesn't use it in a pejorative manner as does Einstein and others. Hence, for Dingle, there is not much point in attaching passion to the argument for or against the idea that the Lorentz-FitzGerald contraction is an ad hoc hypothesis. That passion was reserved to the philosophers of science, who like Popper, attempted to advance a methodological rule that would rule such ad hoc hypotheses out of the bounds of good science. However, that strategy has a demarcation problem, which is to clearly define what constitutes an ad hoc hypothesis, and what characteristics make such hypotheses objectionable. Clearly, some are not objectionable, and it is an important desideratum of the philosophy of science to define this line of demarcation. As we have discussed, Dingle was not interested in advancing this aspect of the debate, but was concerned with the issue of the interpretation of the Kennedy-Thorndike experiment, while Grünbaum was deeply concerned with the problem of the definition of an unacceptable ad hoc hypothesis and this difference becomes apparent as the discussion evolves.

5.2 Grünbaum's Vituperative Response

The force of Grünbaum's response probably surprised Dingle. Grünbaum attempts to deliberately twist Dingle's comments into an indictment of Grünbaum's thesis, and then proceeds to respond as if he was seriously injured by Dingle. Hence he responds as if he is the aggrieved party in the dispute. This is however, mere show. In it Grünbaum deliberately confuses Dingle's historical comments with Grünbaum's different thesis that the ad hoc accusation is not a sufficient logical foundation for the empirical justification of the special theory of relativity.

Grünbaum proceeds to demolish all of Dingle's main points. The effect is certainly spectacular, but he is demolishing a position which Dingle didn't argue for. The only real issue was the question of whether the amount of observational evidence already available provided sufficient empirical support for the justification of the special theory of relativity. Grünbaum contends that there was, and Dingle claims there was not. This is the substance of the issue which was the focus of the debate. The rest of it, was as Dingle says, "mere verbiage".

Grünbaum demolished Dingle's historical arguments and then proceeded to attack Dingle's plea for new independent experimental verifications of special relativity rather than repetitive re-verifications of the same experiments already performed.

On the question of verifying the first postulate, Grünbaum says nothing, but regarding the second postulate, he fires off all of his big guns. He cites all of the evidence for the refutation of Ritz's hypothesis, which claimed that light velocity is defined relative to the source velocity. According to Grünbaum, additional confirmatory experiments are always nice, but in this case totally unnecessary, because the evidence is conclusive. Hence, there really was no need to perform any more experiments, according to Grunbaum.

5.3 Dingle's Response

Dingle responds in a short note as if mystified by Grünbaum's vituperative assault. He says he is not sure what "Grünbaum is now saying". He notes that he considers the argument not worthy of protracted discussion. He then states rather boldly his thoughts on the matter by saying: "..that Professor Grünbaum's statement that the Kennedy-Thorndike experiment could falsify the contraction

hypothesis incorrect….No conceivable result of the experiment could have falsified the contraction hypothesis, or even increased the probability of its falsity. ” With this he challenges Grünbaum’s main thesis.

The reader is probably surprised that Dingle would make such a bold statement, contradicting relativistic dogma. The essential issue is basically the claim made by Grünbaum that the Kennedy-Thorndike experiment is the empirical foundation of the logical basis for the special theory of relativity. Dingle says simply that this claim is false. It must have certainly angered Grünbaum. One can almost hear him shouting; “I will get that heard headed SOB Dingle, Damn him!” What Dingle is doing is withholding affirmation, and this really twists Grünbaum nose.

5.4 Grünbaum’s Concluding Rejoinder

In his concluding rejoinder, Grünbaum sets out to meet Dingle’s bold challenge to prove his point. As it turned out this was not easy. Grünbaum’s concluding rejoinder is rather long and difficult to understand. It is charged with a sense of urgency and verbal bombast that far exceeds the importance of the issues being contended. It seems disconnected and not very cogent to this writer. For example Grunbaum says:”…Professor Dingle’s criticism turns entirely on dubious principles of inductive reasoning, which he invokes with equanimity as if they were integral to our funded knowledge of scientific methodology.”

The basic problem is that there was such a wide philosophical gulf between Dingle and Grunbaum that it could not be understood in the course of the simple exchange of letters. Here we will try to strip away the useless metaphysical rhetoric and deal only with the main substantive issue that Dingle was defending. That was the claim by Grunbaum that the Kennedy-Thorndike experiment provided the required experimental warrant for the special theory of relativity. Dingle rejected this claim and asserted that it really didn’t provide any proof of the claims of relativity. Here we see that Dingle’s focus was not on philosophical disputation, which Grunbaum excelled at, but was concerned with the empirical evidence and its interpretation.

6.0 What The Debate Was Really About

The substance of the debate was centered upon the problem of what constitutes the empirical basis for the special theory of relativity. In Einstein’s version of the empirical justification, the failure to experimentally establish the existence of an absolute light medium, suggested that the principle of relativity, previously established for Newtonian mechanics, was valid when extended into the electromagnetic realm of Maxwell’s equations. Hence both mechanics and electrodynamics obey the principle of relativity. In this context, there was no need for an ether as a heuristic conception.

In Lorentz’s version of the problem, the ether was a heuristic or model conception that provided a basis for the interpretation of Maxwell’s electromagnetic equations. But this interpretation appeared to be experimentally contradicted by the Michelson-Morley experimental results. The solution provided by the contraction hypothesis appeared to be a satisfactory way out of the dilemma. It saved the ether heuristic and could be logically deduced from the Maxwell equations via the transformations which bear Lorentz’s name, but were originally deduced by Voigt. However, the contraction hypothesis was unsatisfactory because it possessed the appearance of being ad hoc.

This however, was overcome when it became clear that the contraction effect was a valid consequence of the Lorentz transformations. With this step, the contraction hypothesis became experimentally indistinguishable from Einstein’s similar theory. But Lorentz went further than this. He insisted that the contraction hypothesis have a physical cause, and this was provided in his detailed analysis, which gave a physical reason for the contraction in terms of a physical theory of the way in which the physical structure of matter containing charged particles was affected by motion through the ether so that there was a physical contraction. This was not just an ad hoc hypothesis, it was a physical theory that explained the contraction by a physical theory of matter. In this sense it was far superior to the philosophically motivated principle of relativity which was essentially metaphysical, because it required a faith in its truth that followed from principles of philosophy and not any kind of physical reasoning as in Lorentz‘s theory.

In his arguments for justification, Einstein relied upon the ad hoc argument to advance the idea that the hypothesis of a principle of relativity was more natural than a hypothesis of a physical contraction. This was a necessity because his reliance upon the principle of relativity did not provide a physical explanation but relied upon a philosophical principle of explanation. But, since his theory also contained the contraction result, it was not clear how the contraction effect in his theory was different from the contraction effect of Lorentz and FitzGerald from a purely empirical viewpoint.

To make the difference clear, we will define it as follows. Lorentz assumed the ether heuristic, which was stationary with respect to absolute space. The contraction effect was asymmetrical such that for any two relatively moving reference frames, the one with the longest measure of length was the slower relative to the ether frame, and this frame could be clearly defined as the one for which the longest measure of length applied. In Einstein's theory, all inertial frames were stationary frames, and the contraction effect was symmetrical, which contradicted the idea that the contraction effect applied to rigid bodies, although that interpretation was also given to it in some cases. This resulted in the problem of whether the effect was real or apparent, and this philosophical problem was never satisfactorily resolved. In Einstein's theory the contraction effect was only valid for observations made from a stationary frame, of objects at rest in a moving frame. It was implicitly assumed, but not proved, that the standards of measure were the same for all possible inertial frames so that they were all identical from the point of view of being equivalent stationary frames.

With the acceptance of Einstein's viewpoint, it became mainstream physical dogma that absolute space was a false conception, so that not only was there no absolute space or time there was also no such thing as the ether. Hence by the 1930s Georg Joos was able to confidently state in his textbook Theoretical Physics that: "*Experiment has thus decided against…the existence of a stationary medium carrying light; i.e. the existence of a cosmic ether or absolute space is disproved.*" (Italics in the original for emphasis) Unfortunately Joos statement entails two problems. The first problem is that it prohibits the existence of the redefined ether as embodied by Einstein's general theory of relativity. Second, like most statements which assert that experiment has proved relativity to be true, is unfortunately false. No such proof indisputably exists, and this is the reason for the debate between Grünbaum and Dingle. Grünbaum claimed that the Kennedy-Thorndike experiment was able to show that the Lorentz-FitzGerald contraction effect as specified by Lorentz's theory was disproved by experiment, thereby demonstrating the non existence of the ether. Dingle disputed this claim and argued that it was impossible that this could be demonstrated by any outcome of the Kennedy-Thorndike experiment. Although Grünbaum resisted this claim, he was eventually forced to reverse his position. Hence the result is clear, or ought to be so. The result is this: There is no valid claim made by experiment that supports the assertion that experiment disproves the existence of a light medium or absolute space and establishes the special theory of relativity as true as a result. This claim is certainly true for the Michelson-Morley and similar experiments, as well as the Kennedy-Thorndike and similar experiments. Hence the difference between Dingle and Grunbaum can be reduced to the conclusion that Grunbaum asserted that there was empirical warrant for Einstein's principle of relativity and Dingle asserted that this claim was false.

7.0 Publications Following The Dingle-Grünbaum Debate

This section examines the results of the Dingle-Grünbaum debate of the early 1960s. If the debate is to be judged based upon a clear winner, it would seem that Grünbaum won based on his mastery of argumentation skills. Dingle on the other hand, did not debate the issues so much as deny Grünbaum the satisfaction of his agreement with Grünbaum's thesis regarding the logical foundations of relativity. If we are to judge the debate on the merits of the positions taken by the participants, as judged by the accepted dogma, again we must see Grünbaum as the winner. But if we are to judge the debate on the basis who was ultimately right, then the outcome is certainly reversed, because the judgment of history went against Grünbaum. There is another criterion which can be applied. That is to ask whether the debate was fruitful in terms of whether it produced useful and interesting results. In this case, the results were indeed fruitful because it stimulated interest in the problem of ad hoc hypotheses, and led to a more careful analysis of the experimental foundations of the special theory of relativity. The purpose of this section will be to examine these consequences.

7.1 Melbourne G. Evans Refutes Grunbaum's Argument

In the December 1969 issue of Philosophy Of Science, Melbourne G. Evans published a detailed analysis that refuted Grunbaum's thesis. His analysis showed that certain aspects of Grunbaum's analysis were false. Here a detailed discussion of the paper will not be presented, but merely a brief discussion of the highlights.

In the conclusion Evans says: "…that certain aspects of Grunbaum's argument are false to the facts, and that he has misconstrued what is essential to the difference between the Michelson-Morley and the Kennedy-Thorndike experiments….It has likewise been shown that on the ether theory, the negative outcome of the Michelson-Morley experiment is fully satisfied by the length ratio…and that the FitzGerald-Lorentz contraction hypothesis…constitutes an illicit interpretation of this ratio…The Fitzgerald-Lorentz contraction hypothesis is false simply and entirely on the grounds that it contradicts the ether theory…It stands condemned, therefore, on the grounds of this contradiction, and there is no need to argue, as Grünbaum has done that it is falsified by any empirical result."

He then goes on to admit that if one takes into account the simultaneous length contraction and time dilation effects, as Dingle maintained in his argument with Grunbaum, that the above result is "erased". But he then goes on further to remark that this is not consistent with the Lorentz transformations so his earlier result is confirmed as valid. He supports the conclusions of relativity but not because the Lorentz-FitzGerald contraction is ad hoc or empirically disproved, but because he shows it is basically a false hypothesis. As it stands, however, this result is not very helpful in understanding if the empirical experiments do provide the necessary claimed refutation of the ether theory. This is important because Grunbaum saw this as a necessary empirical result if the theory of relativity was to have an actual empirical claim to validity. As is stood from Evans results, the contraction hypothesis was falsified by analysis, and the failure to produce the required empirical support was therefore no longer needed.

7.2 Herman Erlichson Refutes Evans Argument

In the December 1971 issue of Philosophy Of Science Herman Erlichson published a commentary on Evans paper in order to "clarify and correct some of the points in Evan's paper."

Erlichson takes issue with Evans claim that the contraction effect is inconsistent with the ether theory. Erlichson says: "Evans is mistaken in his argument…Hence, Evans' claim that the Lorentz-FitzGerald contraction is inconsistent with the ether theory is wrong." So now there is no theoretical disproof of the contraction hypothesis and we need the empirical results again to disprove this hypothesis. Erlichson goes on to discuss the problem of a combined contraction with time dilation, and appears to reach the conclusion that this is indeed the case, justifying Dingle's claim against Grunbaum. Therefore, there is no empirical support that disproves the ether theory. Erlichson goes on to cite Ives, who advocated an ether theory, and argues that the Ives-Stillwell experiment gives evidence in support of Dingle's combined length contraction time dilation interpretation of the experiments that does not empirically rule out the ether.

7.3 Conclusion

It is clear that the outcome of the discussion was not that Grunbaum's assertions were valid, but instead that there was a lot of uncertainty regarding the actual status of the empirical foundations of relativity. One can only deduce from this that there is no clear and certain empirical disproof of the ether hypothesis contained in the Michelson-Morley and Kennedy-Thorndike or the later related experiments of this type.

8.0 Summary, Conclusions, and Comments

8.1 Summary

The discussion was initiated by Dingle's commentary upon Grünbaum's criticism of a thesis advanced

by Popper. There were two main lines of argument. First was Grünbaum's contention that the Lorentz-FitzGerald contraction hypothesis was not ad hoc. This argument was advanced in view of the then current relativity dogma that the Lorentz-FitzGerald contraction hypothesis should be rejected on the basis that the hypothesis was ad hoc, and therefore a violation of sound methodological rules of scientific method. Dingle's response was that the hypothesis was certainly ad hoc when it was suggested by FitzGerald and first considered by Lorentz, but that when later incorporated into Lorentz's theory it lost its ad hoc character and became falsifiable on the basis of the claims of that theory. Grünbaum attacked these assertions and refuted them. Dingle responded by declaring that he was not really interested in this, but was concerned primarily with the problem of the interpretation of the Kennedy-Thorndike experiment, which was being asserted by Grünbaum. This turns out to be the essential point of disagreement, and main reason for studying this issue.

The real issue, as it developed, was not the problem of the ad hoc hypothesis of Lorentz and FitzGerald, but the question of the reality of the Lorentz-Einstein length contraction. The purpose of Grünbaum's comment was to make clear the role of the Kennedy-Thorndike experiment in establishing that the Lorentz-FitzGerald contraction effect had definitely been disproved by experiment. This was intended to clearly establish the interpretation attributed to Einstein, that asserted the length contraction effect was not physically real but the result of a perspective for the viewpoint of two observers in relative motion.

Dingle, as we have seen, was intent upon the drawing out the relativists, with the objective of making them clarify their positions on the issue of length contraction. Dingle's position on this is certainly ambiguous, but this was not unusual. For Dingle, the reality of length contraction was the foundation of the theory. The contraction of length being the foundation for the dilation of time. One could certainly not deny the reality of the Lorentz contraction and then turn around and assert the reality of time dilation, for in Dingle's view they were dual concepts, intertwined and inextricable from each other. The reality or unreality of one entailed the same for the other. Hence we can see why Dingle rejected Grunbaum's argument that the Kennedy-Thorndike experiment refuted the Lorentz-Fitzgerald contraction effect.

The debate later attracted the interest of other writers and the analysis by Melbourne G. Evans supported Dingle's view that the Kennedy-Thorndike was not a decisive test of the Lorentz-FitzGerald contraction versus the Michelson-Morely experiment. Hence these experiments did not perform the crucial test of the contraction hypothesis as relativity texts imply.

8.2 Conclusions

This writer believes that the primary source of the mythological history discussed in the background section, which Grünbaum objects to, is Albert Einstein's campaign to establish a context of justification, as best seen in his 1910 and 1911 relativity papers. This tends to militate against Grünbaum's argument for a philosophical history that places the arguments in their proper logical context, since Einstein demonstrated that he believed that the mythological approach, which became the standard dogma, was the best argument for the justification of special relativity. However, it should be noted that the standard dogma is not exactly Einstein's argument, because he does not actually deny the ether but pronounces it as a meaningless concept. This point has been a source of confusion and will continue to be so in the future, since now almost everyone believes that Einstein proved that the ether doesn't exist, and resistance to criticism of special relativity centers around the idea that relativity critics seek to resurrect the ether in its 19th century conceptual embodiment.

The main point for the present discussion is that the Lorentz-FitzGerald contraction hypothesis made it possible to understand the null result of the Michelson-Morley experiment, within the context of then current physics, without recourse to a new physics. This is of course exactly why proponents of the ensuing new physics of relativity find it is necessary to label this hypothesis as ad hoc with a pejorative connotation, because this provides the context of justification for the new physics of the theory of relativity. Because this new physics was seen as providing many fruitful new results, it was embraced and accepted, despite its rather obvious, and glaring, logical flaws. Unfortunately, Grünbaum realized that this ad hoc justification was inadequate. He attempted to justify the foundation upon an experiment which disproved the Lorentz-FitzGerald contraction, but this attempt failed as becomes clear in the debate with Dingle and the follow up analyses that conclude that the Kennedy-Thorndike is no better able to experimentally refute the contraction hypothesis than was the Michelson-Morley

experiment.

Thus philosophers of science are still embroiled in an unresolved argument for empirical justification of the new relativity physics. However physicists seem unaware of this uncomfortable reality. To satisfy the demand for an empirical sanction of relativity, a large number of experiments have been interpreted in physics textbooks as proof for the theory, although not one of them uniquely tests the fundamental assumption that all inertial rest frames are empirically equivalent in the strict sense that they all require the same standards of measure. It is an overlooked irony that experiments which claim to prove that relativity is correct actually disprove it, since they demonstrate that this fundamental assumption is false. Those tests which all result in a null, contradict the requirement of the theory to exhibit real time dilation effects. Hence, experiments which exhibit time dilation contradict the null results of the Michelson-Morley and Kennedy-Thorndike experiments which exhibit no such effects. Hence, it is certain that there are no clear indisputable experimental proofs that special relativity is valid.

As seen in the debate between Grünbaum and Dingle, the interpretation of an experiment is dependent upon what the theorist thinks the experiment proves, and not what it actually may or may not really prove to be true. Experiments have the disadvantage that they can only test theories when the theories which they test are well defined and have clear unambiguous truth claims that can be definitely and uniquely deduced from the hypotheses. As we see in the case of the foundational experiments of relativity, this is easier said than actually demonstrated. Hence, what an experiment actually proves is filtered by theory, and this can be twisted to be consistent with different interpretations and not yield a definitive result. This is the case with the Michelson-Morley and kennedy-Thorndike experiments of relativity. They provide no clear unambiguous sanction for the theory as claimed that they do.

The main effect of the discussion between Grünbaum and Dingle was that it opened the door to a rather long debate and investigation of the empirical foundations of the special theory of relativity. The most significant aspect of this was Grünbaum's sudden reversal of his position as pronounced in his vice-presidential address to the History and Philosophy of Science section of the AAAS, given December 29, 1963. This sudden reversal could only have been due to the re-examination of his views in light of the debate with Dingle.

The result of all of this is that it has not been clearly established that there exists an empirical warrant, or experimental basis, for the foundation of the special theory of relativity. Thus we see that all of the claims that the special theory is proved experimentally dissolve into a morass of confusion and contradiction, because there is no experimental basis for the special theory of relativity at all that can be definitely proved when it is closely and carefully examined in a critical manner.

8.3 Concluding Comments

It probably will seem to many a bold statement to deny the experimental verification of special relativity given the mountain of evidence that apparently supports it. However, the lesson to be learned here is that theories tend to produce confirmatory evidence, especially if they are thought to be true, simply because it is easier to publish such confirmatory claims, than the opposite. Further, an experimental confirmation of a famous theory generates much press attention and the experimenter is positively perceived as performing good science. Since it is the perception of being a good scientist that leads to promotions, it is obvious that there exists a very strong bias against views which contradict the established dogma.

An experimental refutation is faced with many difficulties, it is therefore better to produce confirmatory evidence, than the opposite. Unfortunately, this has led in the case of the special theory of relativity to a belief that experiment confirms the theory when it clearly does not. This paper has examined the claim that the Michelson-Morley experiment, which was previously thought to be proof for special relativity, was really not such proof, and that the substitute experiment which was proposed, the Kennedy-Thorndike experiment, also does not provide the desired proof. It is curious that both of these were thought to be irrefutable proof of special relativity is correct, and then it was later discovered that these claims were false. This leads to the obvious conclusion that all experimental evidence that claims to support the special theory of relativity is also suspect if they make the claim to have experimentally proved that the special theory of relativity is true.

This project started out with the objective of examining the debate between Dingle and Grünbaum so that it could be understood who had the correct position. It soon evolved into quite a different project when it was realized that the fundamental issue was the experimental justification of the special relativity theory. Grünbaum's claim that the Kennedy-Thorndike experiment was the proper experimental justification of the theory was discovered upon further research to be false. Hence it was discovered that there is no solidly valid experimental foundation for the theory.