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THE SPECIAL THEORY OF RELATIVITY: ITS ASSUMPTIONS AND IMPLICATIONS

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Abstract

Since Albert Einstein proposed the Special Theory of Relativity in 1905, there has been much discussion, concern, and confusion. This theory is probably the most controversial concept within physics and has been the subject of no little controversy in the origins debate. It is not the intent of this paper to defend or refute the theory, rather to clarify what is and is not assumed and what is and is not implied by it. Thus, hopefully this will reduce the confusion and perhaps some of the unprofitable element of the controversy.

Introduction

There are two basic assumptions underlying Einstein's Special Theory of Relativity (STR): the speed of light in a vacuum appears the same to every observer regardless of their motion and the laws of physics appear the same in every inertial reference frame. To Einstein, the first assumption implied the absence of an ether and any physically measurable absolute reference frame. The second assumption does not per se prescribe what the laws of physics are, just that they be consistent to different observers. Once these two assumptions are made, one can, using calculus, derive the Lorentz contraction, time dilation, change in apparent mass, and the famous energy relationship. It is these derived relationships, and in some cases their misinterpretation, which give rise to the controversies surrounding the STR.

The Unstated Assumptions

Einstein made at least two unstated assumptions in developing the STR: orderliness and causality. Without the assumption of orderliness, there is no point in pursuing the study of physics. If phenomena do not occur in a regular manner, then experiments would not be repeatable and it would be absurd to attempt to apply logic and mathematics to increase our understanding of nature. Even if it is incorrect, the STR, if nothing else, is an attempt to develop mathematical expressions for certain relationships between causes and effects. The notion that the STR somehow assumes or even proves that the cosmos is chaotic and thus cannot be understood is false. On the contrary, in developing the STR, Einstein assumed the very opposite to be the case: an orderly, causal cosmos which could be understood by means of logic mathematics.

The Ether Question

The concept of a ubiquitous ether was the subject of much debate near the end of the nineteenth century. Today it is thought by most physicists to have been as thoroughly discredited by Michelson and Morley as the concept of a flat Earth was discredited by Columbus and Magellan. This, however, is not the case. What Michelson and Morley did obtain was a null result for the motion of an ether with respect to the Earth. What they did not obtain was any result enabling one to distinguish between the at least three remaining logical alternatives: (1) there is no ether, (2) the ether moves with or is attached to the Earth, or (3) the ether, much like a viscous fluid, attaches to whatever body it contacts and is thus entrained or "dragged along" with the Earth.

Many physicists consider the annually varying aberration of fixed stars perpendicular to the Earth's orbit which was reported by Bradley in 1728 (Michelson p. 121) to be evidence that the ether is not entrained by or "dragged along" with the Earth; thus eliminating alternative (3) but not necessarily (2). Michelson investigated a number of tests related to Bradley's aberration beginning with Airy's problem in which the telescope was filled with water rather than air. Airy reasoned that if Bradley's aberration was to be explained by the motion of the telescope relative to the stellar light source as the light traveled through the telescope, then the magnitude of the aberration should depend on the refractive index of media inside the telescope. However, this experiment yielded a negative result which was subsequently explained by Fresnel, "that the luminiferous medium is carried along by the motion of the medium; not, however, by the full amount of this motion, but by a fraction . . ." (Michelson, p. 139). Michelson performed several tests of Fresnel's hypothesis. Michelson, however, did not consider this a satisfying proof as he continued his search for such an experimental test. Had Airy's test been positive without resorting to Fresnel's explanation and thus requiring yet another null hypothesis to be experimentally proven, Bradley's aberration would have been a much stronger test against alternative (3). That Michelson was not convinced by the positive results of Bradley's observation and subsequent negative results obtained by related experiments is illustrated by,

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> It must be admitted, however, that these experiments are not sufficiently conclusive to justify the hypothesis of an ether which is entrained with the earth in its motion. But then how can the negative results be explained? (Michelson, p. 155.)

Michelson specifically stated in several places (e.g. pp. 162, 164, 166) that all three alternatives were equally supported by his experiments. What is rarely mentioned is why alternative (2) was rejected by most physicists: because it implies that the Earth has a very distinctive place within the cosmos. This latter notion is inseparably linked to the question of origins. Thus, to preclude or assert it from the outset amounts to an additional presupposition, which eventually may be called a logical foul involving circular reasoning if subsequent developments are used to discredit or confirm the notion.

It is quite possible that no optical experiment can be devised by which a clear determination can be made between the three alternatives. Michelson was unable to devise one, although he devoted many years to this pursuit. The space program may eventually provide an opportunity to test alternative (2). Thus, at this time the question as to the existence of an ether has not been conclusively answered. Moreover, these questions may not ever be answered by direct measurements involving light. To speak as if this were a closed case without the elusive experimental test of the hypothesis is presumptuous.

An Exchange Of Absolutes

The invariance of the speed of light in the absence of an ether has not been unquestionably established. On the other hand, it has not been unquestionably refuted either. Therefore, one may stipulate this as an assumption and continue in order to see if any useful developments follow—all the while being mindful that any subsequent developments rest upon this assumption. It is important to note that Einstein assumed that the speed of light was a universal physical absolute. Because of the STR corollary that there is no absolute frame of reference, it is often implied—if not directly stated—that the STR somehow assumes or even proves that there are no absolutes of any kind. Actually, the STR does not eliminate or deny absolute references, it exchanges them: an absolute frame for an absolute velocity. Einstein argued that the latter was to be preferred over the former, not that all absolute references were to be rejected.

Interestingly enough, this misconception about the STR and absolutes is sometimes extended from the physical to the metaphysical, so that it might be said by some, "even as Einstein proved that there is no absolute physical reference frame, so there is no absolute reference for morals." Whether or not this thought entered into Einstein's head, it is not consistent with the assumptions or the results. Arguably, the implications of the STR could be stated, "one cannot completely trust physical measurements without first comparing these to the standard: the speed of light." If any extension of the STR were to be made from the physical to the metaphysical it should be more accurately stated, "one cannot completely trust an intuitive measure of the morality of a thing without first comparing this to the standard: the character of God."

An Exchange of Principles

Next let us consider which principles Einstein preserved and which he forfeited in developing the STR. It is important to note that the second assumption stated the consistency, not the form, of the laws of physics from one inertial reference frame to another. Whether Einstein carefully weighed each principle and decided which to keep and which to reject, the result is the following: the STR preserves the conservation of momentum and energy, and forfeits the conservation of mass and the unbiased measurement of mass, length, and time. This amounts to an exchange, not a denial, of principles: spatial objectivity is exchanged for the invariance of the speed of light—to many a disadvantageous, even inconceivable exchange. It is at this point where many part company with Albert Einstein and his theory. Again, let me stipulate this bewildering exchange in order to proceed and see if any useful developments follow.

The Old and the New Physics

It can hardly be overstated that the STR revolutionized modern physics; but at the same time the STR is built upon the foundation of classical physics. The challenge of the STR is to revolutionize without destroying and thus undermining itself. Recall that the STR preserves the conservation of momentum and energy while forfeiting the conservation of mass and the unbiased measurement of mass, length and time. This immediately gives rise to the question that if classical measurement of mass, length and time were used to infer the principles of the conservation of momentum and energy from phenomena as being manifestations of nature, the forfeit of any one over another is self-contradictory. Were it not for the asymptotic behavior of the resulting relationships, such that at even seemingly great speeds, spatial objectivity holds, the STR would be hopelessly contra-logical; and logic cannot be forfeited or exchanged in such matters—as is the attempt with dialectics—for from what vantage point could one argue the logic of this exchange?

The Apparent vs. the Actual

Perhaps the most common misconception regarding the STR is that it implies that mass, length and time changes are a function of velocity. This is a misstatement. The STR implies that mass, length and time APPEAR to change with velocity. What the STR claims to provide is a set of mathematical formulae which relate mass, length and time as they appear to one observer to that which appears to another—the unifying factor being Einstein's universal physical absolute: the speed of light. Recall that the second assumption upon which these relational formulae are based is that the laws of physics (viz. the conservation of momentum and energy) are consistent in every inertial reference frame.

The STR claims to describe the relationships between various measurements biased by velocity. The STR assumes that there is only one spatial absolute: the speed of light. What the STR cannot provide is any relationship between the apparent and the actual—if such a thing exists. Furthermore, Einstein concluded that there must not be any spatial actuality—that there is no absolute reference frame. This, of course, is

conjecture. Just because the STR is unable to provide any further relationships beyond the apparent, and even if the stipulated assumptions are correct, inability to relate does not imply nonexistence. The conclusion of the STR with respect to the actual could be stated: if there is an absolute reference frame, it cannot be found by means of physical measurements; and if one were within that frame, there would be no means of recognizing it as such.

Circular Inconclusiveness

The theoretical inability of the STR to distinguish between the absolute reference frame—if such exists—and any other inertial reference frame closes back on the question of an ether. Recall that Michelson admitted that his experiments equally supported alternatives (1) or (2). Therefore, if an absolute reference frame does exist and we are indeed within it, neither Michelson nor Einstein can offer any evidence to the contrary.

There is still the question that if there is no means of determining whether or not we are in the absolute reference frame or whether such a thing exists, does it matter? Whether or not something like this "matters" is a philosophical question and cannot be answered by physics. Philosophically, whether or not this is so matters greatly as to origins. Philosophically then, as stated previously, if there is an absolute reference frame and we are indeed within it, then the Earth has a very distinctive place in the cosmos.

What Then of the Theory?

There are arguable assumptions underlying the STR; and there is the exchange of absolutes; and there is the exchange of principles; but is this not the case with other theories—granted mostly to a lesser degree? If one is willing to do so, the STR can be evaluated on the basis of pragmatic contribution. Are there any phenomena which can be explained by the STR? The answer to this question is: yes. For instance, the STR explains how one can raise the energy of an electron above 0.51 meV. Does the STR explain all particle phenomena? The answer to this question is: no. For instance, the STR is incapable of explaining the existence of behavior of quanta. Are there any phenomena which cannot be explained by any theory other than the STR? The answer to this question must be: we do not yet know. Alternate explanations of phenomena have been presented. See Barnes, 1984, for a recent bibliography and Slusher and Ramirez, 1984. What then of the STR? It does provide some useful results; and could be used with caution.

Conclusions

It has been presented that Einstein in developing the STR assumed both orderliness and causality. Thus, the STR cannot logically be used to refute either of these concepts. It has been presented that the STR rests upon an assumption that has neither been conclusively proven nor disproven. Thus, logically the STR is no stronger than its weakest assumption. It has been presented that the STR exchanges rather than denies absolutes. Thus, the STR cannot logically be used to argue against absolutes. It has been presented that the STR retains some principles, includes an additional one, and forfeits others. Thus, the STR must walk a logical tightrope in order to revolutionize without destroying its foundation. It has been presented that the STR only relates apparent quantities, but does not relate or even address actual quantities. It has been shown that the STR involves circular inconclusiveness. Thus, the STR predicts of itself that it cannot be conclusively confirmed or refuted using physical measurements. Also, it has been suggested that if there is pragmatic contribution of the STR, then it could be used with caution. Finally, it is suggested that, since the STR does assume orderliness, causality, and absolutes; it does preserve some principles; it relates only apparent quantities and it has some utility. It is incapable of addressing ultimate questions; and is therefore, in its basic assumptions, not necessarily supportive of either side in the origins debate.

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