

Einstein's Theory of Relativity: Half Science, Half Philosophy.

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ABSTRACT

This paper discusses how relativity physics woven around Einstien's theory of relativity superseded Newtonian physics which had run into a crisis. The cosmology projected by Newtonian physics has been invalidated by the Michelson-Morley experiment and FIzeau's tube experiment. These experiments demonstrated the impossibility of absolute motion measured from the stand point of immovable ether, absolute time and absolute space which operated as cornerstones of Newtonian physics. The combined theoretical efforts of Hendrick Lorentz and Henri Poincare led way to the founding of theory of relativity by Albert Einstein. The theory resolved the crisis of Newtonian physics by its revolution in the concepts of universal frame of reference, space, time, motion and gravitation attraction which it discovered to be relative and interdependent on one another. Succinctly put, the revolution brought by Einstein's theory of relativity are: that the speed of light in free space has the same value for all observers, regardless of their state of motion; the categories of space, time and motion have an inner necessary connection with one another and are relative and not absolute as Newtonian physics had maintained; and finally the abolition of Newtonian action at a distance. This paper further states that the revolutions in the cosmological structure and dynamics made by the theory of relativity were so radical that some of them are not yet susceptible to experimental checks. This experimental deficit makes the theory of relativity to be half science, half philosophy. The paper makes the conclusion that the theory of relativity, like all great truths, embodies and bridges the fundamental dualities of idealism and realism, subjectivism and objectivism, science and philosophy and reflects the high principle of unity and diversity.

KEY WORDS: Theory; Relativity; Science; Physics; Philosophy

1. The Transition from the Concepts of Classical Physics to the Concepts of Relativity Physics

The theory of relativity began its history in 1905 with the founding of Special Theory of Relativity(STR) and came to maturity in 1915 in the creation of General Theory of Relativity(GTR).The theory of relativity resulted from an analysis of the physical consequences implied by the absence of universal frame of reference. Therefore, an account of its genesis must of necessity trace the long succession of efforts by scientists, mathematicians and philosopher-scientists to establish a universal frame of reference.

By frame of reference is meant a system of "guide post" relative to which all positions and motions may be measured. All motions exist solely relative to the person or instrument observing it. As an illustration, if we are in a free balloon above a uniform cloud bank and see another free balloon change its position relative to us, we have no way of knowing which balloon



is “really” moving. Should we be isolated in the universe, there would be no way in which we could determine whether we were in motion or not, because without a frame of reference the concept of motion has no meaning (Lawrence, 1968).

The roots of the search for a universal frame of reference is traceable to the Aristotelian picture of the universe in which all motions were measured by reference to some fixed and absolute frame of reference; that is, an ideal or logical motion in the context of which the movement from potentiality to actuality occurred. The earth was once considered as the universal frame of reference when it was thought to be at the centre of the universe. However, the Copernican theory deposed the earth from any preferential position in the universe. The French philosopher and mathematician, Rene Descartes, sought to provide the world a universal frame of reference in his system of co-ordinates which consists of three infinitely extended, mutually perpendicular, straight lines with reference to which every point in space may be located. The limitation of Descartes’ co-ordinates or frame of reference was obvious since its measurement was based and done upon the earth, which is itself in elliptical motion round the sun.

Newton in a bid to furnish a universal frame of reference introduced his concepts of absolute space and absolute time. To Newton, absolute space and absolute time were unrelated and independent of one another. All motions in the universe could be referred to them and there was considerable freedom as to what frames of reference could be used in solving common problems involving motion. The space and time frames, because they were considered to be each absolute, were placed on equal footing in applications of the laws of mechanics developed by Newton and Galileo. They are then called inertial frames, that is, they are unaccelerated with respect to each other. They are in uniform motion. Thus, Newton proposed that there is no “privileged” frame of reference. That is, one frame of reference may be as useful as another as long as they are not accelerated relative to each other. This is called the principle of Newtonian relativity.

Newton’s concept of absolute space and absolute time frames went hand-in-hand with the notion of pervading, elastic medium called ether which was thought to fill all space. The ether was then thought to be the medium of transmission of light from its source. Maxwell’s experiments, which showed light to be electromagnetic waves, gave a seeming support to the existence of ether medium because, it posited that light as wave must travel through a medium. However, the failure of the Michelson -Morley experiment to detect any trace of an effect that might be attributed to an ether seemed to portend a crisis to Newton and his fellow physicists of the early years of the 20th century. This is because the concept of absolute space and absolute time and the hypothesis of ether had been the foundations of classical physics. Besides, another consequence of the Michelson-Morley experiment was a new physical principle: that the speed of light in free space is the same everywhere, regardless of any motion of source or observer (Beiser, 1967)

Many attempts were then made to explain the failure of the Michelson-Morley experiment to detect an ether effect. Most noteworthy was that made by George Francis Fitzgerald, a theoretical physicist at the University of Dublin, and H.A. Lorentz, a Dutch physicist. They independently proposed that relative to the absolute frame of the ether, a moving body contracts along the direction of its motion and this contraction off-sets the expected result. From this account, it is obvious that the boundary line between classical physics and relativity physics was the question of the nature and character of ether. Several hypotheses were put forward. The simplest of these were:-

a. The hypothesis of the full involvement of ether by moving matter, and



b. The hypothesis of the absolute immobility of ether.

The first hypothesis was refuted by the results of Fizeau's tube experiment. Fizeau tried to determine how far the movement of matter affected ether by passing a beam of light through water flowing in a tube and then through still water (substance). It turned out that the velocity of the movement of substance had practically no effect on the velocity of propagation of light. The second hypothesis had both great philosophical and physical significance. If it had been experimentally confirmed, it would have provided a philosophical and physical background to the Newtonian absolute space.

The views of Einstein's immediate predecessors, Hendrik Lorentz and Henri Poincare on physical phenomena were shaped by their views in respect of the nature and character of the ether. It is significant that in the history of the genesis of relativity theory, their efforts were the closest steps to the founding of the theory. Einstein could not have broadened and used Max Planck's work without Lorentz's and Poincare's discoveries. These links and relationships deserve closer scrutiny.

Lorentz, guided by ideas of immobile ether, created a theory of electromagnetic phenomenon which made it possible to explain both Fizeau's experiment and other electromagnetic processes. According to Lorentz, the ether was absolutely immobile and this should be noticeable in experiments carried out on earth, moving in ether, in the sense that the movements of matter relative to the immobile ether would be reflected in the effect upon the propagation of beams of light. Furthermore, Lorentz showed theoretically that it was impossible to discover the absolute movement of the earth in ether through an experiment in which calculation of the ratio of the relative velocity and the velocity of light was based on quantities of the first order (i.e. immobile ether and speed of light) (Gribanov, 1987). But unfortunately for Lorentz, Fizeau's tube experiment and Michelson-Morley experiment proved him wrong: there was no effect of movement of matter upon beams of light.

Therefore, to save his theory, Lorentz proposed a hypothesis of contraction. According to this hypothesis, bodies moving relative to ether would contract by a certain amount during their movement. The instruments used in the experiments would consequently also contract and which would offset the expected result. Lorentz's contraction hypothesis expressed the essence of the special theory of relativity even though he did not recognize this. The relativistic essence of Lorentz's contraction hypothesis lies in the fact that it invested each moving object or system of bodies with its own measure of length and time. To consummate his work, he gave a clean mathematical dress to his theory by discovering formulas for the transformation of time and space co-ordinates in various moving systems. These constituted the mathematical basis of STR and are called the "Lorentz transformations".

According to Professor D.P. Gribanov, the weakest spot in Lorentz's theory and which prevented him from being the founder of theory of relativity was his (Lorentz's) idea of quiescent ether as a clear contradiction of the principle of relativity, which had been confirmed in experiments of Fizeau, Michelson and Morley and by Lorentz's own transformation equations. The contradiction, Gribanov argues further, lay in the fact that the principle of relativity, on the one hand, required that the laws of nature be identical in all inertial systems, but at the same time Lorentz's main hypothesis of a quiescent luminous ether singled out systems with a certain state of motion from all systems moving uniformly and in a straight line to those which were at rest relative to ether. Max Born, seemingly of the same view with Gribanov, writes:

“Einstein had then inverted the line of reasoning; what had been a conclusion for Lorentz he put at the start as the postulate of relativity (1905). All the relatively moving systems of reference were of equal status, and each had its own measure of length and time” (cited in Gribanov, 1987, p.197).

Meanwhile, Poincare was as close as Lorentz went toward discovering the special theory of relativity. Poincare saw that the efforts of Lorentz and other physicists to discover the absolute movement of the Earth, that is, its movement vis-à-vis the immobile ether, was wrong-headed. Study of the phenomenon of the refraction and reflection of light had led Fresnel to the conclusion that Earth’s motion did not influence their character. Fizeau in his tube experiment also came to the same conclusion and so did Michelson and Morley. Poincare was of the view that Lorentz transformations were interpreted in a limited way even by Lorentz himself but maintained that Lorentz transformations and contraction hypothesis agreed with the principle of relativity. Also, Poincare drew attention to Lorentz’s idea that the contraction hypothesis does not hold only with electromagnetic forces, but with all other natural forces as well.

Poincare anticipated special theory of relativity further by his rejection of what he described as arbitrary concepts of classical physics such as “absolute time” “the simultaneity of two events” “the equality of two intervals of time”(Gribanov,1987). He clearly comprehended that when one tries to measure physical time, one encounters great difficulties. For instance, he saw it was impossible to take psychological time as the standard of physical time. To measure physical time, Poincare argued, scientists usually employed a pendulum but the amplitude of its swing was not a constant value because it depended on temperature, air resistance, and atmospheric pressure. A more exact measurement of the duration of time was got by the rotation of Earth around its axis. But this too, Poincare noted, was not constant, according to scientists’ statements. It could be affected by tides and the gravitational forces of other planets. But if our instruments were imperfect we could take the duration of two identical phenomena as the standard for measuring the time interval. In terms of time, it should be the same. But since effects in physical reality were not generated by one cause, this determination of time too would be inexact, according to Poincare and so on. Furthermore, Poincare maintained one means of determining simultaneity could be the velocity of light, which physicists believed to be a constant quantity. This postulate, in his view was conditional even though it provided a new rule for quests for simultaneity.

Poincare’s views contained germs of special theory of relativity, yet he did not discover the theory. Like Lorentz before him, he had approached the threshold of the special theory of relativity but failed to take the decisive step. He was hindered, like Lorentz, by basic misconception. He took an idealist position in respect of which nature depended on the perceiving subject in contrast to Einstein’s objective materialist position by which the external world exist independently of consciousness. Poincare’s idealism is well expressed by his following words: “... a reality completely independent of the mind that conceives it, sees it, or feels it, is impossibility. A world as external as that, even if it existed, would always be inaccessible to us” (Poincare, 1905a). Thus, Poincare was led, not to the objective, materialist position implied by special theory of relativity but to agnosticism, a belief shown by his following statement that science can only attain relations between phenomena and not objective reality itself: “But what it (science) can attain is not the things-in-themselves, as naïve

dogmatists think, but only the relations between the things; outside these relations there is no knowledgeable reality” (Poincare, 1905b)

What Lorentz and Poincare did not succeed in doing, was done by Einstein. He did this by finding a synthesis for all the separate views and facts of the universe thereby at one stroke removing all the difficulties beclouding the physicists of his time. Einstein was able to synthesize the separate views and facts because, according to Louis De Broglie, he was able to penetrate and profoundly understand the essence of physical reality (cited in Gribanov, 1987, p.208). Thus, Einstein synthesized the views of his predecessors in the founding of special theory of relativity.

2. The Postulates of Special Theory of Relativity (STR)

The theory of relativity has two phases in its development: 1905, when the special relativity was founded and 1915 when the general relativity was founded. The special relativity otherwise known as the special theory of relativity has its historical origin in a study of electromagnetic phenomena. It takes its name from the denial of the concept of absolute motion and the consequent recognition that only relative motion has any physical significance. However, the theory does recognize a preferred class of observers even though it denies that it is meaningful to ask which of them is at rest in any absolute sense. Thus the qualification “special” signify a hope that it might ultimately be superseded by a theory in which all observers are treated as equivalent.

The special theory of relativity has two postulates. The first states that the laws of physics maybe expressed in equations having the same form in all frames of reference moving at constant velocity with respect to one another. This postulate expresses the absence of a universal frame of reference. By way of analysis, the kernel of this postulate is that if the laws of physics had different forms for different observers in relative motion, it would be determined from these differences which objects are “stationary in space and which are “moving”. But because there is no universal frame of reference, the distinction does not exist in nature, hence the above postulate.

The second postulate states that the speed of light in free space has the same value for all observers, regardless of their state of motion. An illustration will help bring out the force and radical nature of these postulates. In the figure below,



We have two boats 'A', and 'B', with boat 'A' at rest in the water while boat 'B' drifts at the constant velocity V . There is a low-lying fog present, and so on neither boat does the observer have any idea which is the moving one. At the instant that boat 'B' is abreast of boat 'A', a flare is fired. The light from the flare travels uniformly in all directions according to the second postulate of special relativity, even though one of them is changing his position with respect to the point where the flare went off. The observers cannot detect which of them is undergoing such a change in position since the fog eliminates any frame of reference other than each boat itself and so, since the speed of light is the same for both of them, they must both see the identical phenomenon.

The special theory of relativity which treats problems involving inertial frames had the first experimental confirmation in the famous Michelson-Morley experiment which proved that there was no ether. The non-existence of ether then means that there was also no Newtonian absolute space and absolute time. It is in the destruction of the concept of ether, absolute space and absolute time that, the relativity theory struck the strongest revolution in physical science and ushered in the era of contemporary science. This assertion is supported by the fact that the revolution in conception of space and time brought in its train many revisions in theoretical physics and, in turn, in experimental and applied physics. For instance, the phenomenon of light became intelligible and speed of light came to be known as a universal constant; motion in its absolute sense became outmoded and superseded by the concept of relative motion, and finally, matter and energy fell into a reciprocal relationship in the relativity equation: $E=MC^2$ in which e , m , c respectively denote energy, mass, and Speed of light.

The revolution of special theory of relativity in the concept of space and time essentially lies in the fact that the mutual independence of time and space assumed in Newtonian physics and expressed in the phrase, "space and time" became untenable in the light of relativity physics, gained the support of physical experiments. Thus the interconnection maintained by relativity physics between space and time is expressed in the phrase, "space-time" became untenable in the light of relativity physics. The interconnection between space and time according to relativity theory lies in the fact that the space occupied by a body (its size) is affected by its motion (rate of

change of distance). An illustration of how space varies with varying motion is this: Everything in a train travelling along a straight railway will appear shorter to the observer in the direction of the train than it does to a passenger in the train. Also, dinner plates which the passenger sees in the train as circular will appear oval to the observer (Russell, 1968). Because of the interdependence of space and time and their dependence on motion, it became obvious that there is no universal frame of reference, no absolute time and space. Rather, space and time are qualities of a particular body in motion relative to some other body or of a particular system of bodies relative to some other.

It must be noted, however, that the interconnection between space and time does not mean that there is no longer any distinction between space and time. There are time-like intervals and space-like intervals. But the distinction is of a different sort from that made in classical physics. The distinction is that there is no longer a universal time which can be applied without ambiguity to any part of the universe. There are only the various “proper” times of the various bodies in the universe which agree approximately for two bodies which are at rest relatively to each other.

Besides the revolution in the conception of space, time, motion, light, and matter already discussed above, the theory of relativity has another very important radical feature; and this that although distances and times vary for different observers we can derive from them the quantity called “interval”, which is the same for all observers. The “interval” in the special relativity theory is obtained as follows: We note the square of the distance between two events and the square of the distance by light in the time between the two events; then we subtract the lesser of these from the greater and the result is defined as the square of the same for all observers and represents a genuine physical relation between the two events which the time and the distance do not. This interval which is a physical constant is established to be numerically equal to the speed of light in a vacuum. Nonetheless, the special theory of relativity has a limitation which is that it does not consider non-uniformly accelerated frames and systems. In other words, it does not deal with motions resulting from gravitation. Thus, the need arose to discover a system that will include gravitation. Such a system is the general theory of relativity to which we now turn.

3. The General Theory of Relativity (GTR)

The general theory of relativity is a logical development of the special theory of relativity. In other words, it arose from the extension of the principle of relativity to account for gravitation. The special theory of relativity considers inertial frames or uniform motion. It does not consider non-uniform motion which arises from gravitational effects on bodies. That it does not consider the effects of gravitation means that it segments or separates out a system of bodies in uniform motion to which the laws of nature would apply. This bracketing or separation of a privileged class of systems in which bodies are in uniform motion (inertial frames) neglects the possibility or fact of there being other systems with varying or non-uniform motion, for example, systems in accelerated, slow-speed, circular, and rotational motion. Thus, there was the need logically from the founding of special theory of relativity for there to be a theory that would



cover and account for all systems of bodies both uniform and non-uniform. Einstein realized this limitation of the special theory of relativity and this was why he named the theory “special” theory, with the hope that there would emerge a theory that would supersede it (Russell, 1968). On this, Einstein wrote: “That the special theory of relativity is only the first step of a necessary development became completely clear to me only in my efforts to represent gravitation in the framework of this theory” (cited in Pathria, 1974).

To show the validity of his conclusion that gravitational forces were responsible for certain kind of acceleration of systems, Einstein cited the following mental experiment: He imagined two experimenters who are sitting in a closed, moving room, who did not know either their location in world space or their state of movement. How could they determine what was happening to them: was their room in motion or in a state of rest? They could try dropping various objects onto the floor. If they fell, then one of the experimenters had the right to say that their quarters were at rest on some celestial body, and the objects were drawn by this body toward its centre. But the other experimenter could equally rightly say that their laboratory was moving in cosmic space with acceleration due to some mechanical force. The objects retained their state of rest as a result of inertia and only created an impression of falling (Gribanov, 1987).

Einstein concluded from the fact of the equality of inertial and gravitational mass which he demonstrated by the above mental experiment that all processes occurred in a uniform gravitational field in the same way as in a space in which there was no gravitation, but which had an equivalent field of inertial forces generated by uniformly accelerated motion. The indistinguishability of the effects of inertia and gravitation, therefore, suggested that an inertial system with a uniform gravitational field was physically equivalent to a certain non-inertial system. And this already provided reasons for extending the principle of relativity to non-inertial system. Thus the general theory of relativity which states that all frames of reference, including non-inertial ones are equivalent as regards description of nature is inextricably woven with gravitation. Gravitation is both its cause and effect. Hence, Einstein studied gravitation closely before he formulated the theory. A profound study of gravitation enabled Einstein to discard Newton’s law of gravitation which maintained that between any two particles there is a force which is proportional to the square of their distance. In the framing of this law, Newton maintained that the sun attracts all material bodies thereby inventing what he called “action at a distance” by which he meant the invisible force of sun’s attraction on distant bodies.

In formulating the general theory of relativity through a closer study of gravitation Einstein also discarded Euclidean geometry of space and time having found that gravitational forces affect the metrics of space and time. Einstein became aware of the weakness of Euclidean geometry through discovering that the temporal rhythm of clocks placed at the centre and periphery of a moving disc depended on their distance from the gravitational centre of the disc. Also, the lengths of measuring rods fastened to a rotating disc tangential to its circumference and along its radius should differ by virtue of the fact that moving bodies are contracted from the point of view of stationery observer thus Einstein concluded from these facts that: “This proves that the propositions of Euclidean geometry cannot hold exactly on the rotating disc, nor in general in gravitational field” (Gribanov, 1987). Based on his new theory of gravitation Einstein formulated the three postulates of the general theory of relativity as follows:



1. That the interval between neighboring events takes a general form. This means that bodies left to themselves do their journeys as slowly as they can, it is a sort of law of cosmic laziness.
2. That everybody travels on a geodesic in space-time except in so far as non-gravitational forces act upon it. This postulate is better explained by the following picture. In the neighborhood of a piece of matter, there is, as it were, a hill in space-time. This hill grows steeper and steeper as it goes near the top, like the neck of a champagne bottle. It ends in a sheer precipice. Now by the law of cosmic laziness a body coming into the neighborhood of the hill will not attempt to go straight over the top, but will go round. This is the essence of Einstein's view of gravitation. What a body does, it does because of the nature of space-time in its neighborhood, not because of some mysterious force, emanating from a distant body.
3. That a light-ray travels on a geodesic which is such that the interval between any two parts of it is zero. This means that light travels in straight lines and its speed in free space is a universal physical constant.

The upshot of Einstein's law of gravitation is then that the sun is not the source of gravitation; it does not pull the planets. Since the sun is itself moving as a part of the solar system, it cannot be absolute frame of reference of all motion for there is no physical occurrence which can be called "absolute motion". The bodies move on their own by the principle of inertia and this motion of the body is equivalent to gravitation prevalent in the body's locality. That is, inertia mass is equal to gravitational mass. This is what is called the "principle of equivalence" and leads logically to the general theory of relativity which maintains that all frames of reference are equivalent. That is, all laws of nature have a general form; hence, constant no matter the frame of reference employed.

4. The Integration of STR and GTR as the Birth of Relativity Physics

This section presents a summation of the physical principles of relativity physics which are the necessary result of theory of relativity. The founding of the theory of relativity made for itself foes and friends alike. Thus, there is about it a great circle of controversies but it has made irreversible revolution physics.

The first short of the revolution struck at the nature of space and time. In classical physics, these quantities were considered absolute and independent of each other. But in relativistic physics today, these quantities are relative and inter-connected. That is to say that the space and time orders of events are in part dependent on the observer. They are not in themselves objective physical facts. But there is nevertheless an objective physical fact which can be inferred from the distance in time together with the distance in space. This is mathematically calculated and it is what is called the "interval" in space-time. This interdependence between space and time is the occasion of the use of the term, 'space-time' in relativity physics.

Relativistic physics also rejects the notion of absolute motion of classical physics as expressed in Newton's "first impulse". It says the phenomenon of motion is relative. That is to say that all bodies are in motion relative to others. For instance, when it is said that something moves, it is meant that it moves relatively to the earth. The planets (including the earth) are

moving relatively to the sun or to the centre of mass of the solar system. When we say that the solar system itself is moving, we mean that it is moving relative to the stars. Relativistic physics says there is no physical occurrence which can be called “absolute motion”. Therefore, the laws of physics are concerned with relative motions because these are the only kinds that occur.

Another important discovery of relativity physics is the experimental fact that the velocity of light is the same relatively to one body as relatively to another however the two bodies may be moving. This constant velocity of light in free space has therefore provided a universal physical constant used in calculation of dynamics of bodies in modern physics. Classical physics had its constant in the ether.

Furthermore, in relativity physics, gravitation assumes a new character. The sun is no longer the cause of gravitation as it was maintained in classical physics. Rather bodies move in accordance with the law of cosmic laziness or the principle of least action which states that in passing from one state to another, a body chooses a route involving less action than any slightly different route. The discovery of this character of gravitation has therefore destroyed the classical physics notion of force.

Finally, in relativistic physics, measured energy and mass (matter) are regarded as the same thing as demonstrated in the relativity equation $E=MC^2$ and they assume a new fluidity in accordance with the rapidity of the prevalent motion. But in classical physics, matter and energy were not so linked. There was relative independence and matter was considered as a piece which survived all through time.

All these conceptual revolutions which relativistic physics compels have far reaching implications for the way we should correctly comprehend the nature and rationality of the universe. Such far-reaching implications have generated the debate whether theory of relativity is a science or a philosophy; a debate which is both the inspiration and subject of this paper.

5. Einstein’s Theory of Relativity: Half Science, Half Philosophy

The theory of relativity from its early days has generated what can now be described as a perennial debate which is centered on its scientific status given that the wide breadth of the theory did not make it susceptible to the usual experimental check except the mental experiment and mathematical representation through which the author tried to make it intelligible. For sure, the author, Albert Einstein (1879 to 1955), received Nobel Prize in 1927 for his scientific genius but it was for his work on photoelectric effect and not for his founding of the theory of relativity because the debate and controversy the theory provoked did not allow it to be recognized as a scientific achievement. The debate remains unabated and, consequently, the theory swings between science and philosophy. These points of debate are elucidated below although it must be stated that they are not exhaustive in so far as scientific research is bound to progress.

One of the points of debate concerned the velocity of light. The velocity of light plays a fundamental role in the theory of relativity. There are two facts about light which makes it fundamental in the theory of relativity. First, that nothing is known in physics which travels with greater velocity than light. Second, that the velocity of light is the same for all observers. Great uses are made of these facts about the velocity of light. The universal character of velocity of light is used conventionally for the purpose of coordinating units of length and time. The fact

that nothing in physics travels faster than light makes our determinations of simultaneity depend on signals transmitted with the speed of light. Also it gives a general physical distinction between paths which can be travelled by matter and those which it cannot. This is usually called “light barrier”. It is found that the nearer the velocity of matter approaches to that of light, the greater is the energy required to accelerate it faster. It would require an infinite amount of energy to reach the speed of light. This escalating energy requirement, which obviously rules out breaking the light barrier manifests itself as a progressively increasing inertia (mass) of the body (Eddington, 1920).

Sir Arthur Eddington argues in his book, *Space Time and Gravitation* that it is because of this light barrier phenomenon that it is often said that nothing can travel faster than light. But he quickly added that in strict terms this is not true because it is only material objects that cannot be accelerated though the “light barrier”. Therefore, he argued that it is possible to have entities that travel as fast as, or even faster than light provided they are always superluminal, i.e. cannot be slowed to less than light speed (Eddington, 1920).

Interestingly enough, such superluminal bodies, called *tachyons*, have now been discovered even though their nature is still controversial. Meanwhile M.G. Bowler (1986), a nuclear physicist at the Oxford University adds to this controversy by observing that:

“Anyone who has learnt relativity has usually been thoroughly indoctrinated with the idea that nothing goes faster than light. A great many velocities exceeding C (velocity of light) are encountered in physics. These may cause confusion and distress”

The discovery of these superluminal particles brings with it a number of problems: They are said to interact with matter in an uncontrolled way and therefore causes an apparently irresolvable paradox, that is, it may be shown from the theory of relativity that these superluminal bodies can travel backwards in time so that their use as a signaling device would facilitate communication with the past. In that case Arthur Eddington argued that one could then construct a booby-trapped device which would destroy itself by a coded signal sent to its past, thereby removing the possibility of sending the signal in the first place – an obvious contradiction. It is beyond the scope and subject of this paper to juggle with the controversies of the existence of superluminal bodies and their character but it is noteworthy that the existence of superluminal bodies has dethroned light from its privileged position in the theory of relativity as a universal constant and this portends great crisis theoretically and practically.

Another controversy which detracts from the empirical status of the theory of relativity is that generated by the high-flown mathematics of the theory. Many physicists and philosopher scientists are not impressed by the nearly ethereal or out-of-the-world mathematics in which the theory is tucked away from plain understanding. Eddington (1920), for instance wrote that:

“The mind is not content to leave scientific truth in a dry husk of mathematical symbols..... The mathematician who handles x so lightly may fairly be asked to state, not indeed the inscrutable x in nature, but the meaning which x conveys to him

It is knowledge of structural form and not knowledge of content”

Bertrand Russell, on his part, observes in his book, *The ABC of Relativity 1968* that:

“It is generally recognized that he (Einstein) revolutionized our conception of the physical world, but the new conceptions are wrapped up in mathematical technicalities. It is true there are innumerable popular accounts of the theory of relativity, but they generally cease to be intelligible just at the point where they begin to say something important...what is demanded is a change in our imaginative picture of the world—a picture which has been handed down from remote, perhaps pre-human, ancestors and has been learned by each of us in early childhood”

Besides, such excessive mathematics as is regretted above is a pure type which therefore casts the theory in pure ideal forms and makes the extraction of physical facts or “contents” in the words of Eddington perplexingly difficult. This is why V.F. Mitkevich in his book, *Basic Physical Opinion*, praised the absence of excessive mathematics in Michael Faraday’s work on electricity and called on physicists to develop a bent for physical thinking freer from the influence of mathematics (cited in Griбанov, 1987, p.29). Also, S.I. Vavilov writes that “The mathematical abstractness of the new theoretical physics is well known and incontestable.... One asks how far this abstractness is necessary and inevitable...”(Cited in Griбанov,1987, p.29)

There is no doubt that if Einstein had rendered his theory in less abstruse mathematics, it would have been better understood and the air of indeterminacy and concomitant polemic surrounding it would not have existed. However, it might be that when he intuited the delicate and obscure truths of relativity he had no choice but to turn to mathematics render it communicable through the tools of ideal mathematical symbols. Ironically, it is these ideal mathematical forms in which the theory was delivered that makes it share close neighborhood with philosophical truths just as Pythagoreans in their mathematical tradition shared closer kingship with philosophy than with science.

Further controversy which questions its scientific status concerns the experimental status of the theory. It is a common knowledge that the two beacons of relativity, namely, the constancy of speed of light and the equivalence of inertial and gravitational mass are not susceptible to physical experiment although certain physical experiments (like the Michelson-Morley experiment which proved the non-existence of the ether phenomenon) have supported certain other facts of the theory. This is why A.K. Timiryazev , a Russian scientist, regretted that the theory “is very well insured against experimental checking”(Cited in Griбанov, 1987, p.16) while Maximov ruefully observed that “mental experiment flourished in Einstein’s work”. Maximov went further to say that:

“The mental assumption of observations of velocities vastly removed from everything accessible to us, mental



“juggling with clocks and determination of simultaneity, mental demonstration of the equality of inertial and gravitational mass did not give the much-desired scientific status to Einstein’s work” (Cited in Gribanov, 1987, p.20)

Besides, Einstein has been accused also by Maximov of introducing metaphysics into physics by placing the constancy of light at the level of “absolute immutability in physics”

Beyond the above debates which have led to the question of the theory of relativity being half science and half philosophy, there are further complementary reasons in support of the theory being a philosophy. These reasons are summarized by the view that the theory of relativity has prodigious amount of philosophical thoughts because of its radical or fundamental character. In the first place, the theory of relativity has destroyed the philosophical conception of the world held to us by classical physics of Galileo and Newton. The imaginative and philosophical revolution the theory has impacted on its reflective readers and researchers cannot be reversed.

Under classical physics matter and energy were considered to have relative independence and matter on its own was thought of as a piece which survived all through times. But relativistic physics destroyed the close-knit mechanical universe of the classical physics and gives us the conception of a universe that is somehow fluid (note length contraction, time dilation and retardation), relativistic, and steadily evolving and hence capable of infinite extension in space - time. This new conception of the universe will dawn on us when we note that in relativistic physics, in contradistinction to classical physics, measured mass and energy are regarded as the same thing in the equation, $E=MC^2$; that length contraction/expansion and time retardation/dilation occur with increasing or decreasing rate of motion, and that the history of the whole spectrum of human knowledge leads with logical necessity to an evolving, indeterminate universe.

Also, gravitation as presented by Einstein’s theory of relativity is a minus to a mechanical conception of the universe and a plus to a fluid, relativistic, and evolutionary conception of the universe. According to relativity theory, the sun is no longer the cause of gravitation as it was in classical physics. Rather, bodies move in accordance with the law of cosmic laziness. The result of bodies moving in accordance with the principle of cosmic laziness is the destruction of the concept of “force” as presented by Newtonian physics. Hence, there is no “governing force” in the universe of moving objects to maintain an order of a mechanical universe.

The deep philosophical character of theory of relativity is to be seen in the way it absorbs and explains within its matrix the old philosophical opposites, idealism and realism. At one turn, it supports idealism against realism. At another turn, it refutes idealism and supports realism. This paradox is characteristic of the great, comprehensive truths of the universe: they often clothe themselves in obscurity and reveal their elements in ironies. This is unarguably one of the reasons for the mounting polemic amongst scientists and philosophers on what should be the authentic interpretation of the theory vis-à-vis modern science and traditional philosophical problems. If we remind ourselves that idealism is the conclusion that the universe is an expression of intelligence and will, that the enduring substance of the world is of the nature of



mind, and that the material is explained by the mental, we will begin to see how relativity theory justifies idealism against realism.

This justification of idealism and refutation of realism by relativity theory lies in the analysis of the theory's standpoint on matter, space – time, and its famous equation, $E = MC^2$. In the light of such analysis, we see that matter has lost its old inertness and concreteness to fluid categories of space – time. Also, matter ceases to be the hard piece that survives all time. It can thus be resolved into series of events. Also the implication of the theory of relativity that motion (a metaphysical category) determines the quantity of mass is a triumph for the idealist tenet that the spiritual or metaphysical is primary and matter secondary.

Furthermore, space – time, the order in which matter exists under theory of relativity is amenable to idealist interpretation because they are not objective categories before the eyes of all observers. They are subjectivist-idealist categories. The famous theoretical physicist, Ernst Mach supported this subjectivist-idealist interpretation of relativity theory in his influential philosophy of science called sensationalism by which he posited that a thing (matter) is identifiable with our sensations of it; this is to say that for Mach, physics studies ideal objects. Arthur Eddington, an eminent physicist, pointed out that “space-time are not things inherent in the external world” (Eddington, 1920.).

Finally, the theory of relativity equation, $E = MC^2$, justifies idealism because in this equation measured mass and energy are regarded as the same thing. On this view, the greater part of the mass of matter is due to concealed energy which is not as yet released. Calculations of charged particles moving with high velocities showed that the electrical inertial (mass) of the particles are not strictly constant but depends on the speed of the particles. In all cases, the variation is summed up in the statement that the inertia is simply proportional to the total energy of the electromagnetic field. In other words, the mass of a charged particle at rest belongs to its electrostatic energy. Once again, the inter-convertibility of matter and energy symbolized in the relativity equation upholds the objective idealist view that reality is reducible ultimately to metaphysical or spiritual category. In these ways in which the relativity theory justified idealism, it ipso facto annuls the contentions of realism. Nonetheless, it supports realism in some other ways.

Realism maintains the existence of an objective, extra-mental world. The theory of relativity supports such a world. It reflects objective processes of nature; it recognized the general significance of the laws of nature and by assuming an arbitrary transformation of the coordinate systems, discovered the general laws of this transformation. There is something very essential if one will comprehend the objectivity standpoint of theory of relativity. This is the fact that the theory is talking about *physical* relativity, about an extra-relative, extra-mental world of matter-time-space.

Although length and duration have no exact counterpart in the external world, it is clear that there is a certain ordering of living and events outside us. This ordering is four-fold. It can be arranged as right-and-left, backwards-and-forwards, up-and-down, sooner-and-later. Although different observers separate the four orders differently, they all agree that the order of events is four-fold and it appears that this undivided four-fold order is the same for all observers. It is inherent in the external world; it is in fact the synthesis of the appearance seen by observers

having all sorts of positions and all sorts of (uniform) motion. Hence, it can be regarded as a concept of the real world not relative to any particularly circumstanced observer (Eddington, 1920).

The reason why some scholars attach subjectivist-idealist meaning to relativity theory is partly due to their reading of Einstein's "Observer". Bertrand Russell, in this regard, suggests that it is natural to suppose that the observer is a human, or at least a mind. But he quickly added the observer "is just as likely to be photographic plate or a clock". In this case, Russell argued that "the odd results as to the difference between one "point of view" and another are concerned with "point of view" in a sense applicable to physical instruments just as much as to people with perceptions"(Russell,1968). Relativity theory is talking about *physical* relativity or subjectivity. Furthermore, it is a strictly limited subjectivity. The theory is not saying that everything is relative; on the contrary, it affords a technique for differentiating what is relative from what is a physical occurrence in itself.

Therefore, the essence of the theory of relativity consists in establishing the relative character of temporal and spatial intervals or distance. The magnitude of the one and the other depends essentially on the state of the observer. Any attempt to read subjectivist-idealist meaning into this statement and substantiate it by the arguments of philosophical relativism and rejecting the possibility of over-coming this relativity, will inevitably lead to conversion of theory of relativity into philosophical relativism which it is not. On the contrary, the conception of a four dimensional world overcomes the relativity of measurements of space and time and provides steps toward absolute understanding of the eternal world of matter in motion.

The foregoing support given to both idealism and realism should not be seen as a weakness which would warrant people like Semkovsky(1926) to say that the philosophical views of Einstein suffer from great indeterminacy and Einstein was the worst philosophical interpreter of his theory. Instead, it should be seen as strength. It is the character of great truths of the universe to embody opposites. What is more, Einstein had the genius for synthesizing contradictories. At the centre of his scientific work were such opposites as the continuum, expressed in the development of the concept of field, and quantum theory with its ideas of atomistic discreteness. As Gerald Holton observed:

"Einstein could deal with, use, illustrate, transform the existence of apparent contradictories or opposites... one need only think of his bridging of mechanics and electrodynamics, energy and mass, space co-ordinates and time co-ordinates, inertial mass and gravitational mass" (Cited in Elkana, 1977, p.367).

Thus, there are no conclusive arguments on either the side of idealism or on that of realism. To hold either view exclusively is, in the words of Bertrand Russell, "a dogmatic rather than a scientific temper" (Russell, 1968).

6. Conclusion

The theory of relativity is a mediation of the fundamental dualities of idealism and realism; objectivism and relativism, science and philosophy; a mediation in the sense of incorporating and



accommodating them as dialectical opposites of the truth which it is. Thus the theory of relativity as it is examined in this research is a reflection of the eternal principle of unity in diversity. It does not absolutely support neither idealism nor realism; science nor philosophy. It is a Janus-like truth. To the extent that parts of its teachings are observably experimentable, it is a science. To the extent that they are not, it is a philosophy. Viewed correctly in this way as philosophy and science of unity in diversity, the implicit harmonizing elements in it, I believe, shall build up the impulse towards dialogue and understanding between conflicting classes, and warring nations. In this sense it shall promote constructive pluralism, harmony and peace in the world.

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