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Aether Integration

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Abstract

In this paper we investigate into the possible resurrection for the aether and it's compatibility with the theory of relativity. We revisit the Michelson-Morley experiment and expose some of the major inadequacies. In this regard, we have presented the true/corrected form of the Michelson-Morley experiment. We have tried to revise the interpretational aspect of the mathematical formalism regarding the metric of Minkowskian space-time in addendum with it's relationship to the two theories of time. We herein have also tried to restrain some of the quantum mechanical issues arising from the mainstream understanding of the mathematical formalism of the Minkowskian manifold. Essentially, we have argued in favour of aether to be incorporated into our mathematical formalism as well the physical understanding of the universe.

Keywords: Aether; Lorentz-Poincare relativity; Michelson-Morley experiment

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1 Introduction

Since time immemorial, man has been pondering about the nature of space and time. The notion of relativity has been around since the time of Galileo and maybe even before that. In his Annus mirabilis, Sir Isaac Newton single-handedly drew the map of the entire foundation of the modern science, building upon the works of Galileo and using the Aristotelian metaphysics of space time. Albert Einstein in 1905, gave the first major revision to the Newtonian model of the universe by introducing his revolutionary idea of relativity, which relativizes all of the inertial reference frame(s). Einstein established his relativity principle using only a set of two mere axioms/postulates. His postulates were simple but at the same time made predictions of path-breaking results which sort of emerged from the postulates. He used Lorentz transformation to justify mathematically the major ideas emerging from the relativity theory. This is the mainstream narrative regarding the theory of relativity, but as well shall see, the Truth is far more nuanced and complex. Einstein's postulates were simple, yet made path breaking predictions which predicated some very bizarre concepts which at least on first sight, seems paradoxical! However improbable his results may seem, time and time again they have been able to match the experimental evidence which was brought forth to contend with it. indeed the theory of relativity is an extremely powerful theory which has literally lies at the foundation of the entire modern civilisation. Yet, despite all it's predictive power and brilliance it simply falls short when one transitions into the quantum realm. Quantum field theorists have been trying to completely unite the two theories for decades now. It seems perhaps that there is indeed something missing from Einstein's special relativity. In his (inset year) paper : Two theories of relativity, the mathematician Elener Clad Resigner, has pointed out that, while the theory of Einsteinian relativity needs two axioms, the Lorentz formulation, upon which the entire edifice of SR is built, needs only one axiom. Professor Resigner, stresses the importance of the minimal axiomatic setup of the theory of relativity to keep the mathematical rigour intact. Along with all this and the reductionist interpretation of the null result of the Michelson - Morley experiment, we tried to explore the possibility to design the theory of relativity with the notion of the aether built into the formalism of it and then see if the results match with the established results from SR. In the process of researching for this, we were absolutely astonished to find a plethora of publishes papers on ideas of the same vein. To our astonishment, the French mathematician, Henri Poincare had already work out the theory of relativity, a year before Albert Einstein, without announcing the notion of the aether as "superfluous". Emily Adlam from the university of Oxford, in her 2011 paper : Poincare and Special Relativity, shuns Poincare for his "traditionalist" and "conventionalist" doctrines and praises Einstein's revolutionary Bohemian type approach towards science, but as we shall see in this paper, that the psychological underpinnings for such varying epistemologies among people are

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not so simple.

Initially we thought of assuming a priori that the aether exists and then working out the wave equations accordingly but then we realised that Poincare and Lorentz had already done work along these lines so we became more curious. We couldn't find any significant literature on this so we went down the rabbit hole and found a literature on this topic and hence our curiosity rose and we decided to explore it accordingly.

The paper is organised as follows. In section 2, evidences are laid out in favour of the preferred reference frame. A contrast is also drawn between the so called A and B - theories of time. The limitation of the Minkowskian interpretation is perfectly laden through this discussion. In section 3, we carve out certain features of Lorentz-Poincare relativity and a comparison and contrast between the Lorentz-Poincare relativity and Einsteinian relativity is made and is shown that the latter is a limit of the former. This is then followed with a brief introduction to the Michelson-Morley experiment in section 4. The inconsistency of this experiment is also narrated which is resolved by elucidating an example in which the accurate form of the experiment automatically arises. In section 5, a model is created in which the aether is re-introduced and certain phenomenologies are described as well. In section 6, we give some important highlights of the Einstein-Aether theories. Finally the paper is closed with some important conclusions.

2 Special reference frame and the aether

The existence of a special/preferred reference frame is undoubtedly quite important for the modern day physics as it flies right into the face of SR, but some other aspects for the existence of such a frame of references may solve problems regarding quantum mechanics. For instance, the EPR paradox. This section of the paper argues for the existence of such a special frame.

In [cite Quantum preferred frame], a preferred frame in the context of the quantum mechanical realm has been proposed with an Einstein-Podolsky-Rosen type scenario. The mechanism involves a pair of observers coexisting in the same inertial frame and the use of massive EPR pair of spin-1/2 or spin-1 particles. It is realised that for observers in the same inertial frame, the predictions of quantum mechanics coupled to a preferred frame are identical as in the non-relativistic quantum mechanical scenario where there is no such frame of reference involved. In addition to this, an important inequality, called the Bell-Mermin inequality given by,

$$C^1(\mathbf{a},\mathbf{b}) + C^1(\mathbf{b},\mathbf{c}) + C^1(\mathbf{c},\mathbf{a}) \leq 1 \tag{1}$$

is violated in the standard relativistic quantum mechanics for a particular configuration while the preferred frame quantum mechanics (PFQM) does not violate it. Furthermore, Lucien Hardy in his paper, [cite Phys.Rev. Lett. 68(1992)] proposed a gedanken experiment which suggests that any realistic quantum theory should possess an absolute notion of simultaneity or identically, a preferred frame of reference. Indeed, the deep problems of quantum mechanics are solved much more conclusively by integrating the notion of the preferred frame in it's formalism. While the incorporation of the preferred frame solves the quantum mechanical problems, problems of cosmology also gets addressed.

In [cite CMB as preferred frame], a model incorporating the basic principles of special relativity with a preferred frame (in this case the cosmic microwave background) has been proposed. This model has been applied to the computation of the CMB temperature distribution and has found that it gets rid of the inconsistency of the traditional approach when the Einstein's relativity, from which the notion of preferred reference frame is absent, are used to determine the consequences of motion with respect to the special frame of reference. This said model, yields the same results as that of SR while at the same time is able to explain some new novel scenarios. Such a construction of the theory of relativity with the integration of the notion of a preferred frame of reference can also been seen in the works of Jacobson and Mattingly who have suggested a possibility of a preferred rest frame (aether) at each point in space-time [cite Gravity with a dynamical preferred frame and Relativistic Gravity with a dynamical preferred frame]. In these works, they have studied in an attempt to sought a viable effective field theory while incorporating a breaking of local Lorentz invariance. The preferred frame, aether, is mathematically realized by a unit timelike vector field u^a and it preserves rotational invariance. The authors seek to incorporate the preferred frame while preserving the notion of general covariance which further asks that the preferred frame be dynamical. The major advantage in doing this is that the preferred frame is skillfully introduced while also preserving the consistency of the Einstein field equations $G_{ab} = 8\pi G T_{ab}$.

In [cite Reviving Gravity's aether in Einstein's universe], Afshordi has put forward comprehensive arguments in favour of reviving the old aether concept back into the current theories as reintroducing the idea of "gravitational aether" has potential to address problems in quantum gravity and cosmology. He puts forward a proper reasoning which goes as, "the underlying principles or symmetries of an effective theory might be accidental or emergent symmetries of a more fundamental theory. As powerful as the principle of relativity might have been in the development of Einstein's theory of gravity, it might need to be broken/re-examined, e.g., by having a preferred reference frame, or a gravitational aether, in a more complete theory of gravity". A modern day version of the gravitational aether can be represented by,

$$T'^{\nu}_{\mu;\nu} = \frac{1}{4} T^{\nu}_{\nu,\mu} \tag{2}$$

For the gravitational aether model, an action principle that could lead to the required equations is yet to be achieved [cite Afshordi3]. However the action is only needed if one wants to have a quantized description of gravity, while the field equations,

$$(8\pi G')\, G_{\mu\nu} = T_{\mu\nu} - \frac{1}{4} g_{\mu\nu} T^{\alpha}_{\alpha} + p'(u'_{\mu} u'_{\nu} - g_{\mu\nu}) \tag{3}$$

assuming that they can be consistently be solved, are sufficient with the classical and semi-classical approach to gravity.

Jacobson has discovered that in a theory with preferred frame effects, the dynamical alignment of the frame (or frames) can be explored to figure out the stability of cosmic alignment [cite Cosmic alignment of the aether]. The same can also be used to characterize the range of the initial conditions that could be expected to naturally align. The motivation behind this is to know whether it is natural or not, for the aether to be aligned with the isotropic frame of a homogeneous, isotropic cosmology in the Einstein-Aether theory or Horava gravity. The research concludes that the aether does align subject to some constraints, with one of them requiring that the tilt angle and its derivative w.r.t. time in units of Λ, the cosmological constant, are smaller than something of order unity.

In [1], a model of charges, assumed as singularities in the aether has been conceptualized which is unwavering with relativistic principles. The model has also been demonstrated to be equivalent to the Maxwell's equations with the charges. However the model is consistent only when the Lorentz-Poincare interpretation is presumed, instead of the Einsteinian or the Minkowskian interpretation. The paper also presents certain features of Einstein's and Minkowski's interpretation which seem to be in contradiction whereas the Lorentz-Poincare formalism resolves those problems satisfactorily. In this section the salient points of [1] is presented whilst bestowing the appropriate judgements wherever required. Subsequently, a portion of [1] is investigated where it is stated that instead of the two axioms of STR, there is requirement of more axioms, some of which are just conventions and some are experimental facts. We shed our light on the justification of those axioms. Our exploration is based on the Lorentz-Poincare interpretation as it is found to supersede the Einsteinian and Minkowskian interpretation as evident from the analysis of [1]. The prime reason to follow this is due to the fact that, only the Lorentz-Poincare interpretation is found to be indicating as well as advocating the existence of a special frame of reference which is one of the main concerns of our paper. This interpretation of relativity theory is also consistent with the aether model, which is another central concern of this paper alongside the preferred frame.

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2.1 Salient arguments of Simeonov's paper

* Simeonov wrote down three basic equations which sort of represented his mechanical model of charges in aether [1]. We reproduce the equations here for reference:

$$\frac{\partial}{\partial t}A(r,t) = \rho(r,t)v(r,t) + \nabla\phi(r,t) \tag{4}$$

$$\rho\frac{\partial v}{\partial t} = -c^2\nabla \times (\nabla \times A) \tag{5}$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho v) = 0 \tag{6}$$

In this model, although the density of the aether is not constant, it is preserved in the presence of charges. Also, the proposed framework is equivalent to the Maxwell's equations. Quoting Simeonov, "Thus, in order to obtain the customary Maxwell's equations, the charge should have the same local velocity of the aether. But why should this be so, unless the charge is part of the aether, a kind of singularity in it, which blasts away or draws in aether with a constant rate. We can speak therefore of a constitutive aether."
* Simeonov threw light upon some of the significant, empirically grounded data which seem to indicate towards the existence of a special reference frame [2].

* The paper depicts some prominent advantages of the Lorentz-Poincare interpretation which turn out to be hugely supportive for the idea of a preferred frame and the aetheric model. Some of them are restated here,

(i) It undertakes the A-theory of time whereas the Minkowskian assumes the B-theory.

(ii) It can be broken down to two simple postulates - the existence of a preferred frame (of the aether) and velocity dependent mass of particles. All the important consequences including the Lorentz transformations can be derived from them.

2.1.1 Axioms and empirical facts

We now discuss the axioms and the empirical facts which is required in a coherent picture of relativity theory. It should be noted that we are presenting Simeonov's analysis of the axioms in a simpler way and have also formulated some axioms with our own methodology.

Axiom 1 (convention): Time flows uniformly at all points in space. In [1], he has shown the truthfulness of his axiom, but we have tried to give a proof of a geometrical nature. Which is as follows, it follows from the initial premises of the A - theory of time as follows:

Since it has been shown in the previous sections the existence of a preferred reference frame or a cosmic/absolute frame of reference, from that it follows that there must exist a frame of reference which is not absolute in it's nature, and the entire three dimensional universe is embedded in that non absolute framework of time since they are temporal in

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nature as they are subject to the flow of time because of which the notion of causality remains preserved in the temporal universe whereas the supposed abstract objects which belongs to the domain of the absolute frame of reference in a-temporal framework, that is to say, they exist "out - side" of time or better yet, "metric time". The absolute/global time and metric time are related through the Lorentz transformation equations because of Lorentz covariance, quoting Simeonov, "If the fields were to propagate with some other finite speed c' say, then Lorentz transformations would have been changed accordingly and we would have had to replace c with c', everywhere. In other words the very presence of c in the Lorentz transformations is an artifact of the field equations. Second, it seems that the reason why all forces are Lorentz covariant is that all fields in nature (that we know so far) propagate with the same speed of light c. If the fields were to propagate with different speeds, we would have different Lorentz transformations for each field". Let us elucidate this with the following "Gedanken-Experiment" : Consider the train experiment wherein a train is approaching a platform where an observer, say O, is also standing. If we breakdown the arrival of the train in frames we would have O divided in three frames. When the train is about to approach, it can be regarded as future, when the train has just arrived - it is present and finally when the train would leave the platform it would be past. However the notion of past, present and the future is simultaneous bridged by the Lorentz factor. The proof of the same is shown below.

A: Special frame→ time in special frame. Since A→ A(t), that is, since A is not scalable to some arbitrary monotonic function without using erroneous results. Because if you change time to some arbitrary monotonic function of time: t→f(t) then,

$$\frac{md^2x}{dt^2} = \alpha(t)F + m\beta(t) + \frac{dx}{dt} \tag{7}$$

this implies, that this time is an absolute quantity, since this is not scalable to some arbitrary monotonic function without introducing erroneous results, see [4 landau lifshitz]. Here we have tried to rephrase a theory in tandem with the metric and the absolute. Let, a_1: past a_2: present a_3: future , hence,

$$A = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} a_1 = \gamma a_1 \tag{8}$$

$$A = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} a_2 = \gamma a_2 \tag{9}$$

$$A = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} a_3 = \gamma a_3 \tag{10}$$

$$\gamma a_1 = \gamma a_2 = \gamma a_3 \tag{11}$$

$$a_1 = a_2 = a_3 \tag{12}$$

The gamma factors cancel each other out in eq.(8) and hence eq.(9) proves that the past a_1, the present a_2 and the future a_3 is simultaneous. Later we realised Lorentz and Poincare did them along the similar lines. Now let a scalar field T on $\mathbb{R}^3$ be defined as,

$$T : \{R\}^3/\{0\} \to \{R\}^+/\{0\}, \forall\, a_1, a_2, ..., a_{n-2}, a_{n-1}, a_n \,\epsilon\, \mathbb{R}^+/\{0\} \tag{13}$$

This implies that there can be infinitely many of them. Therefore also note that a function is smooth if it can be differentiated any number of times. This requires that all the partial derivatives exist and are totally symmetric (i.e. the differential operators are commutative). At this point it is wise to state that a continuos framework actually appears from a scaled up discrete behaviour just like numbers on a number line.

Much like Euclidean space, time can be considered as a set of scalars, a_1, a_2, a_3,..., a_n, hence time is a scalar field. All the properties of a scalar field holds for time as well. Also, scalar field is invariant under any Lorentz transformation. Therefore time is homogeneous and isotropic.

Axiom 2: If $\overline{ABA}$ is same, then the point B is at rest, because of the isometric property of the Euclidean space $\mathbb{R}^3$.

$$|T(\vec{x} - \vec{y})| = |\vec{x} - \vec{y}|, \forall\, \vec{x}, \vec{y} \,\epsilon\, \mathbb{R}^n \tag{14}$$

since, an isometry T from $\mathbb{R}^n \longrightarrow \mathbb{R}^n$ is a distance preserving map, i.e., more concretely,

$$|T(\vec{x} - \vec{y})| = (\vec{x} - \vec{y}), \forall\, \vec{x}, \vec{y} \,\epsilon\, \mathbb{R}^n \tag{15}$$

Eg: reflections, rotations and translations are isometric in $\mathbb{R}^n$. Axiom 2 literally follows from Axiom 1 analogous to the real number property.

Axiom 3 (empirical fact): There exists special systems of points A, B, C,..., such that all points are at rest relative to each other. For the proof let us consider a triangle, say, ΔADC where AC, AD and DC = c. Therefore they must form a triangle which must obey the triangle inequality. In other words, the triangle need not to be equilateral since it can be isosceles as well as scalene because of the triangle inequality.

Let A $\to$ a ϵ scalar. Similarly C $\to$ c ϵ scalar. Now two scalars when joined together geometrically would result into a vector, this is true also with regards to the rotation and orientation. let,

$$\vec{AC} = \vec{u} \quad \vec{CD} = \vec{v} \tag{16}$$

$$\vec{AD} = |\vec{u} + \vec{v}| \leq |\vec{u}| + |\vec{v}| \tag{17}$$

also, it is known that the distance between two points $\vec{p}$, $\vec{q}$ in $\mathbb{R}^n$ is $|\vec{q} - \vec{p}|$ or $|\vec{p} - \vec{q}|$. This implies,

$$|\vec{p} - \vec{q}| = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2} \tag{18}$$

Axiom 4: Select such a system of points which are at rest relative to each other from an infinite number of such systems.

Axiom 5 (empirical fact): Special frames in which round trips are always the same.

Axiom 6: Lorentz transformation maps elements of sets of same manifolds through a specific rule. Since we are using Lorentz transformations which is dependent on 'c', hence synchronisation is natural.

2.2 Theories of time

Time in its own nature is not only physical. Pre-supposition of the same is a categorical mistake made by people, therefore one must take help, in addition, from the philosophers inorder to realise its true character. Time is metaphysical (for the lay readers, it does not mean divine however it may actually be divine in some sense). In this paper a wide spectrum about the nature of time is covered and primarily the focus has been delineated to the works of William Lane Craig who has spent 11 years in studying these areas. Apart from his works we found a significant literature by Richard Swinburne on similar topics. Craig's work has described the Einsteinian and Minkowskian interpretations and by studying him thoroughly we also got accustomed to the fact that there exists two theories of time, namely the B-theory and the A-theory also known as tense and tenseless theory respectively. All scholars agree unanimously to the aforementioned statements.

Initially Einstein interpreted the A-theory and abandoned it later which meant that unknowingly and unwittingly he adopted the B-Theory in favour of the Minkowskian interpretation and in the process he failed to understand the true theory (A-theory) which ultimately was proof of a special reference frame. Quoting [1] on this one, "Therefore what Einstein's special theory of relativity took with one hand (a special reference frame), Einstein's gravity theory gave back with the other". Although leading theoreticians such as Dirac and Bell were in support of the aether model which implied the existence of a preferred frame.

The research data shows that the A-theory is correct however the burden of proof lies on the B-theorist because the B-theory fails to deliver when quantum mechanical situations are introduced which further implies that the Minkowskian interpretation is incomplete if not wrong in totality. The aether is also consistent with A-theory rather than the B, therefore special frame can be deduced from this fact and which further infers metric and non-metric time.

Newton's work was also embedded in the metaphysical but erroneously a postmodernist naturalistic reductionist view was supposed, which is not true, therefore we should

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consider A-theory as the true one. We have slightly modified the description of the A-theory, we are considering it as AAA theory, where the A's represent the past, present and the future and all are bridged by the Lorentz factor into a single global representation of time, as shown in earlier section.

It is also important to note here that Einstein's results on special relativity [5], can be derived using absolute and metric framework where simultaneity is preserved in the absolute frame and relativistic effects can be accommodated or rather emerge in the metric frame. Metric time transforms to absolute time when we reach the speed of light and then there can be no physicality in the absolute domain as non-metric time corresponds to non-local behaviour. This implies that the aethereal frame is nothing but the special frame and universal consciousness is in the absolute frame. Therefore special relativity would be consistent in the former and Newton's absoluteness is true in the latter. Time is discrete in nature and applies to discrete objects in the metric frame, however, it is simultaneous in universal consciousness frame/absolute frame therefore there should be a representation which can coalesce the two frames wherein time comes up as a flat circle. Metric time is cyclical in nature and when we transcend the metric frame, everything collapses in the non-metric time/absolute time. We here state some relevant quotations from the works of W.L. Craig [6, 7].

> "Trapped in our locally moving frames, we may be forced to measure time by devices which are inadequate to detect the true time, but that in no way implies that no such time exists."

> "Einstein's theory may thus be regarded as pragmatically useful and scientifically fruitful without considering that absolute simultaneity and absolute time have thereby been abolished."

> "The present represents the edge of becoming and future events do not merely not yet exist rather they do not exist at all."

> "If every event in the space-time manifold is equally real and existent and God transcends space and time, then he can easily be conceived to cause and sustain (tenselessly) every space-time event regardless of its location."

> "According to the B-theorist, temporal becoming is mind dependent and purely subjective. Time neither flows nor do things come to be except in the sense that we at one moment are conscious of them after not having been conscious of them at an earlier moment."

Here we want to draw attention to a quantum mechanical argument which requires the notion of absolute time. In [cite Entanglement and time] the author argues that the violation of multisimultaneity in experimental tests prove that quantum entanglement occurs without the flow of time. Quoting him on this,

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"In conclusion the experiments testing quantum entanglement rule out the belief that physical causality necessarily relies on observable signals. Quantum entanglement supports the idea that the world is deeper than the visible, and reveals a domain of existence, which can- not be described with the notions of space and time. In the nonlocal quantum realm there is dependence without time, things are going on but the time doesn't seem to pass here."

2.3 Simeonov's revision of Maxwell's equations

James Maxwell ingeniously unified mathematically, the already existing empirical laws discovered by Coulomb, Faraday, Ampere, Ohm and others, into a set of four equations [8]. These well known laws are as follows,

$$\nabla \cdot \mathbf{E} = \frac{p}{\epsilon_0} \tag{19}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{20}$$

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0 \tag{21}$$

$$\nabla \times \mathbf{B} - \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} = \mu_0 j \tag{22}$$

Interestingly, Maxwell build on aether and his equations are valid in the same. Now in [1], Simeonov has shown that electromagnetism is consistent in the aether model constructed by him. Here one can compare the two models by trying to explain a single phenomenon through both the models and then analysing the results. The most obvious in this case would be to obtain the speed of light through Maxwell's and Simeonov's model respectively. We begin with the Maxwell model first.

Consider a closed loop in three dimensions. Then according to the Ampere's law,

$$\oint \vec{B} \cdot \vec{dl} = \epsilon_0 \mu_0 \frac{d\phi_E}{dt} \tag{23}$$

$$\phi_E = \int_0^{\frac{\lambda}{4}} ldz\, \epsilon_0\, cos(kz - \omega t), \quad taking\ time\ derivative, \tag{24}$$

$$\frac{d\phi_E}{dt} = l\epsilon_0(+\omega) + \int_0^{\frac{\lambda}{4}} sin(kz - \omega t)\, dz \tag{25}$$

$$\Longrightarrow \frac{d\phi_E}{dt} = l\epsilon_0(\omega) + \int_0^{\frac{\lambda}{4}} sin(kz - \omega t)\, dz \tag{26}$$

$$= \left[\frac{l\epsilon_0\, \omega}{k}(-cos\, kz)\right]_0^{\frac{\lambda}{4}} = l\epsilon_0 c \tag{27}$$

$$B_0\, l = \mu_0\, l\, \epsilon_0\, c \implies B_0 = \epsilon_0\, \mu_0\, c \tag{28}$$

Now using Faraday's law one gets,

$$c = \frac{1}{\sqrt{\mu_0\, \epsilon_0}} \tag{29}$$

Consider Maxwell's equations in empty space, i.e, $\rho = 0$, j$=0$. Then the equations give,

$$\nabla^2 \mathbf{E} = \nabla(\nabla \cdot \mathbf{E}) - \nabla \times (\nabla \times \mathbf{E}) = \nabla \times \frac{\partial \mathbf{B}}{\partial t} = \frac{\partial}{\partial t}(\nabla \times \mathbf{B}) = \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} \tag{30}$$

Defining $c = \frac{1}{\sqrt{\mu_0\, \epsilon_0}}$, the equations yield,

$$\left(\nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} \right) \mathbf{E} = 0 \tag{31}$$

The above is the wave equation describing propagation with velocity c. Similarly we can obtain the magnetic analogue of the above equation,

$$\left(\nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} \right) \mathbf{B} = 0 \tag{32}$$

Thus Maxwell's equations predict the existence of electromagnetic radiation in free space which propagate with velocity $c = \frac{1}{\sqrt{\mu_0\, \epsilon_0}} \approx 3 \times 10^8\, m\, s^{-1}$, which is nothing but the speed of light. We have seen two different approaches to arrive at the value of the speed of light through Maxwell's model. The first one is the integral form and the latter is the differential form.

Now, Simeonov in his model obtained the wave equation of the form [1],

$$\rho \frac{\partial^2 \xi}{\partial t^2} = -c^2\, \rho\, \nabla \times (\nabla \times \xi) = c^2 \rho \nabla^2 \xi \tag{33}$$

In the words of Simeonov, the above equation demonstrates that light becomes a kind of sound wave in aether. Expounding with more clarity, this means that electromagnetic waves travel in an aethereal medium just like sound waves travel in a material medium. Thus light is a perturbation in the aether.

Maxwell's and Simeonov's results are in parallel to each other, however, Simeonov's analysis has more expository competency and therefore it should be preferred over Maxwell's model.

3 Poincare Relativity

The theory of relativity is one of the major accomplishments of the 20th century. The credit for the formulation of this theory is given to none other than Albert Einstein. Contrary to popular belief, we show in this section that relativity theory was developed independently by Einstein's contemporary, Henri Poincare, at about the same time as Einstein and in a manner which is loftier than that of Einstein. It might be possible that the foundations for the theory was laid out by Poincare well before Einstein. We showcase strong arguments in this favour using noted evidences we have found during our research. All the relevant mathematical equations of relativity and the quotations are presented from the works of Poincare inorder to substantiate our claim. We appreciate the work of [A. A Logunov] because of whom we got accustomed to the works of Poincare and his significant contribution in the development of the theory of special relativity.

In [Poincare1], Poincare wrote: "The relativity principle, according to which the laws of physical phenomena must be identical for an observer at rest and for an observer undergoing uniform rectilinear motion, so we have no way and cannot have any way for determining whether we are undergoing such motion or not". The above preferably suggests that he was referring to Galileo's principle of relativity and he infact did generalize the principle to all natural phenomena in that paper. It can't be denied that this principle became a cornerstone in the development of both electrodynamics and relativity theory. In [A. A Logunov], Logunov states that the Galilean principle of relativity is not included in Einstein's postulates. As he puts it further in his words,

> "It is necessary to specially emphasize that the principle of constancy of velocity of light, suggested by A. Einstein as the second independent postulate, is really a special consequence of requirements of the relativity principle by H. Poincare. This principle was extended by him on all physical phenomena".

In [Poincare2, Poincare3], Poincare first initiated invariance of the Maxwell-Lorentz equations as well as the invariant nature of the equations of motion of charged particles under the action of the Lorentz force with respect to the Lorentz transformations and on the relativity principle, for all natural phenomena. He built upon the work of Lorentz and published them in 1905, the same year Einstein introduced his special relativity [Einstein1]. Above all, Poincare realised that the Lorentz transformations along-with spatial rotation form a group called the Lorentz group and in the process he was also the first to instigate the concept of four dimensionality of several physical quantities. It is so predominant that the entire edifice of theoretical physics would simply collapse without it. Many invariants were discovered by Poincare in this group and amidst them was the fundamental invariant,

$$J = c^2T^2 - X^2 - Y^2 - Z^2 \tag{34}$$

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which is obtained by utilizing the Lorentz transformations. The above equation represents the four-dimensional space-time which later became known as the Minkowski space. The differential form of eq.(31) is given by,

$$(d\sigma)^2 = c^2(dT)^2 - (dX)^2 - (dY)^2 - (dZ)^2 \tag{35}$$

The above represents the geometry of space-time called the pseudo-Euclidean geometry. This geometry was conceived by Poincare and strengthened later by Minkowski. However, people only give this credit to Minkowski erroneously. Logunov writes here,

> "On the basis of the group discovered by Poincare, H. Poincare and H. Minkowski revealed the pseudo-Euclidean geometry of space-time, which is precisely the essence of special relativity theory".

It has been illustrated beautifully in [Logunov], how the Lorentz transformations form the group as realized by Poincare. We reproduce it here for reference to the readers and make this discussion as self-contained as possible. Examine,

$$x' = \gamma_1(x - v_1 t), \quad t' = \gamma_1\left(t - \frac{v_1}{c^2}x\right) \tag{36}$$

$$x'' = \gamma_2(x' - v_2 t), \quad t'' = \gamma_2\left(t' - \frac{v_2}{c^2}x'\right) \tag{37}$$

Swapping eq.(33) onto eq.(34) yields,

$$x'' = \gamma_1\gamma_2\left(1 + \frac{v_1 v_2}{c^2}\right)x - \gamma_1\gamma_2(v_1 + v_2)\,t \tag{38}$$

$$t'' = \gamma_1\gamma_2\left(1 + \frac{v_1 v_2}{c^2}\right)t - \gamma_1\gamma_2\left(\frac{v_1 + v_2}{c^2}\right)x \tag{39}$$

However,

$$x'' = \gamma(x - vt), \quad t'' = \gamma\left(t - \frac{v}{c^2}x\right) \tag{40}$$

Comparing equations (35) and (36) with (37), we get,

$$\gamma = \gamma_1\gamma_2\left(1 + \frac{v_1 v_2}{c^2}\right), \quad \gamma v = \gamma_1\gamma_2(v_1 + v_2) \tag{41}$$

From the above equation, it is found that,

$$v = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}} \tag{42}$$

and finally it can be established that,

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma_1\gamma_2\left(1 + \frac{v_1 v_2}{c^2}\right) \tag{43}$$

Abridging the above calculations, it means that the transition from one reference frame (x^v) to another reference frame (x'^v) and succeedingly, to the reference frame (x''^v) is not different from the direct transition from the reference frame (x^v) to (x''^v). From this, one can argue that the Lorentz transformations form a group as discovered by Poincare. Now, one can also represent the transformations of the Lorentz group in a matrix form, given by,

$$X' = AX \tag{44}$$

where,

$$A = \begin{pmatrix} \gamma & -\frac{v}{c}\gamma \\ -\frac{v}{c}\gamma & \gamma \end{pmatrix},\ X = \begin{pmatrix} x \\ x_0 \end{pmatrix},\ X' = \begin{pmatrix} x' \\ x'_0 \end{pmatrix} \tag{45}$$

$$x'_0 = ct' \quad x_0 = ct \tag{46}$$

Poincare extended the Lorentz group to all physical phenomena and in this regard, he wrote [Poincare3],

> "... All forces, of whatever origin they may be, behave, owing to the Lorentz transformations (and, consequently, owing to translational motion) precisely like electromagnetic forces".

Logunov writes,

> "The presence of Lorentz group automatically provides the synchronization of clocks in any inertial reference system. So the proper physical time arises in any inertial system of reference – the modified local time by Lorentz."

It is important to note here that Poincare derived eq. (31) on the basis of the Lorentz transformations. Surprisingly, if we apply the invariant discovered by Poincare, it would actually lead us to the original Lorentz transformations. This is shown explicitly in [Logunov] and we redo it here for reference.

Let the invariant J in an inertial reference system have the form (31) in Galilean coordinates. Now, we pass to another inertial reference system,

$$x = X - vT, \quad Y' = Y, \quad Z' = Z \tag{47}$$

then the invariant J takes the form,

$$J = c^2\left(1 - \frac{v^2}{c^2}\right)T^2 - 2xvT - x^2 - Y'^2 - Z'^2 \tag{48}$$

Therefore we have,

$$J = c^2\left[\sqrt{1 - \frac{v^2}{c^2}}T - \frac{xv}{c^2\sqrt{1 - \frac{v^2}{c^2}}}\right]^2 - (-x^2)\left[1 + \frac{v^2}{c^2 - v^2}\right] - Y'^2 - Z'^2 \tag{49}$$

The above equation can be written as,

$$J = c^2T'^2 - X'^2 - Y'^2 - Z'^2 \tag{50}$$

where,

$$T' = \sqrt{1 - \frac{v^2}{c^2}}T - \frac{xv}{c^2\sqrt{1 - \frac{v^2}{c^2}}} = \frac{T - \frac{v}{c^2}X}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{51}$$

$$X' = \frac{x}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{X - vT}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{52}$$

Logunov writes here,

> "In deriving the Lorentz transformations from the expression for the invariant we took advantage of the fact that the invariant J may assume an arbitrary real value. Precisely this circumstance has permitted us to consider quantities T and X as independent variables, that can assume any real values. If we, following Einstein, knew only one value of J, equal to zero, we could not, in principle, obtain Lorentz transformations of the general form, since the space variables would be related to the time variable."

Lorentz's local time given by,

$$\tau = T\left(1 - \frac{v^2}{c^2}\right) - \frac{v}{c^2}x \tag{53}$$

permits to perform synchronization of clocks in a moving reference system at different spatial points with the aid of a light signal. Precisely expression (3.12- in [Logunov]) is the condition for the synchronization of clocks in a moving reference system. It introduces the definition of simultaneity of events at different points of space. Poincare established that Lorentz's "local time" satisfies this condition. Now with regards to the simultaneity of events as well, Poincare's work precedes that of Einstein. Quoting [Logunov] on this,

> "So, the definition of simultaneity of events in different spatial points by means of a light signal as well as the definition of time in a moving reference system by means of light signal both were considered by Poincare in his papers of 1898, 1900 and 1904. Therefore nobody has any ground to believe that these ideas have been first treated by A. Einstein in 1905".

It is worthwhile to note here that the introduction of simultaneity for the points of a three dimensional space is an automatic consequence of the pseudo-Euclidean geometry of 4-D space, and in which Poincare's role cannot be avoided.

From [Poincare2, Poincare3], it can be easily inferred that Poincare didn't simply obey Lorentz, rather he escalated upon Lorentz's work and while framing his own insights, completed the theory of relativity in this fashion. In the same works, he expands Lorentz invariance on all the forces of nature, including the gravitational force. He also discovered the equations of relativistic mechanics and the fundamental invariant described earlier. Coming to the invariance of the Maxwell-Lorentz equations, certain factors introduced by Poincare was instrumental in establishing the plausibility of the principle of relativity for electromagnetic effects. Among them was the introduction of the vectors S^ν and A^ν which are given by,

$$S^\nu = (S^0, \vec{S}), \quad and \quad A^\nu = (A^0, \vec{A}) = (\phi, \vec{A}) \tag{54}$$

The relation between the two vectors is given by,

$$\Box A^\nu = \frac{4\pi}{c} S^\nu,\ \nu = 0,\ 1,\ 2,\ 3. \tag{55}$$

It is important to note here that the operator $\Box$, called the d'Alembert operator, is invariant under the Lorentz transformations. Now the coalition of ϕ and $\vec{A}$ into the vector A^ν is mandatory inorder to preserve the symmetrical nature of eq.(42). Automatically, it follows that if in a given inertial frame of reference, only an electric field exists then in the other reference system there must exist a magnetic field inorder to preserve the symmetry and hence let A^ν convert into a vector. This is central to the relativistic effects encountered in electromagnetism. Now, the Lorentz transformations for S^ν are given by,

$$S'_x = \gamma\left(S_x - \frac{u}{c} S_0\right), \quad S'^0 = \gamma\left(S^0 - \frac{u}{c} S_x\right) \tag{56}$$

Considering the components of this vector, it is found that,

$$\rho' = \gamma\rho\left(1 - \frac{u}{c^2} v_x\right),\ \rho' v'_x = \gamma\rho(v_x - u) \tag{57}$$

where,

$$\gamma = \frac{1}{1 - \frac{u^2}{c^2}} \tag{58}$$

u is velocity of the reference frame. Similarly the transformations for S_y and S_z are of the form,

$$\rho' v'_y = \rho v_y, \quad \rho' v'_z = \rho v_z \tag{59}$$

It is striking that all these prescriptions were obtained primarily by none other than Henri Poincare [Poincare2]. The consequence of these relations is,

$$v'_x = \frac{v_x - u}{1 - \frac{uv_x}{c^2}},\ v'_y = v_y \frac{\sqrt{1 - \frac{u^2}{c^2}}}{1 - \frac{uv_x}{c^2}},\ v'_z = v_z \frac{\sqrt{1 - \frac{u^2}{c^2}}}{1 - \frac{uv_x}{c^2}} \tag{60}$$

which is nothing but the relativistic velocity transformation equations. Now in [Logunov], Logunov states: "For consistency with the relativity principle for all electromagnetic phenomena, besides the requirement that the Maxwell-Lorentz equations remain unaltered under the Lorentz transformations, it is necessary that the equations of motion of charged particles under the influence of the Lorentz force remain unaltered, also". He puts the above statement to argue that the aforesaid was done only in Poincare's works [Poincare2, Poincare3]. This is very important to justify that Poincare laid the groundwork of relativity theory before Einstein.

Taking into account the relationship between the components of the tensor $F^{\mu\nu}$ and the components of the electric and magnetic fields, it is possible to obtain the transformation law for the components of the electric field,

$$E'_x = E_x,\ E'_y = \gamma\left(E_y - \frac{u}{c}H_z\right),\ E'_z = \gamma\left(E_z + \frac{u}{c}H_y\right) \tag{61}$$

and for the components of the magnetic field,

$$H'_x = H_x,\ H'_y = \gamma\left(H_y + \frac{u}{c}E_z\right),\ H'_z = \gamma\left(H_z - \frac{u}{c}E_y\right) \tag{62}$$

These formulae were first discovered by Lorentz, however, neither he, nor, later, Einstein established their group nature. This was first done by H. Poincare, who discovered the transformation law for the scalar and vector potentials [Poincare3]. Now, From the formulae for transforming the electric and magnetic fields it follows that, if, for example, in a reference system K' the magnetic field is zero, then in another reference system it already differs from zero and equals,

$$H_y = -\frac{u}{c}E_z,\ H_z = \frac{u}{c}E_y,\ or\ \vec{H} = \frac{1}{c}\left[\vec{u}, \vec{E}\right] \tag{63}$$

From the field components it is possible to construct two invariants with respect to the Lorentz transformations,

$$E^2 - H^2, \quad (\vec{E}\vec{H}). \tag{64}$$

These invariants of the electromagnetic field were first discovered by H. Poincare [Poincare3]. The invariants can also be expressed via antisymmetric tensor of the electromagnetic field $F^{\mu\nu}$

$$E^2 - H^2 = \frac{1}{2}F_{\mu\nu}F^{\mu\nu}, \quad \vec{E}\vec{H} = -F_{\mu\nu}F{*}^{\mu\nu} \tag{65}$$

where,

$$F{*}^{\mu\nu} = -\frac{1}{2}\epsilon^{\mu\nu\sigma\lambda}F_{\sigma\lambda} \tag{66}$$

$\epsilon^{\mu\nu\sigma\lambda}$ is the Levi–Civita tensor, $\epsilon^{0123} = 1$, transposition of any two indices alters the sign of the Levi–Civita tensor. In accordance with the second invariant (61), the fields $\vec{E}$ and

$\vec{H}$, that are reciprocally orthogonal in one reference system, persist this property in any other reference system. If in reference system K the fields $\vec{E}$ and $\vec{H}$ are orthogonal, but not equal, it is always possible to find such a reference system, in which the field is either purely electric or purely magnetic, depending on the sign of the first invariant from (62).

Poincare also presented the four-vector of force R^ν, in the first place and which is another cornerstone of theoretical physics in general and special relativity in particular. This can be expressed as,

$$R = \frac{F}{\sqrt{1-\frac{v^2}{c^2}}}, \ \vec{R} = \frac{\vec{F}}{\sqrt{1-\frac{v^2}{c^2}}} \tag{67}$$

The Lorentz transformations of the above equations would yield,

$$R'_x = \gamma\left(R_x - \frac{u}{c}R\right), \ R' = \gamma\left(R - \frac{u}{c}R_x\right), \ R'_y = R_y, \ R'_z = R_z. \tag{68}$$

Now, the German mathematician Herman Weyl in his book "Raum. Zeit. Materie" wrote [Weyl1],

> "The Solution given by A. Einstein, which has solved all difficulties by one strike, is as follows. World is a four-dimensional affine space in which a metrization is enclosed by means of an indefinite quadratic form $Q(x) = (xx)$ with one negative and three positive dimensions".

Here, $Q(x) = -x_0^2 + x_1^2 + x_2^2 + x_3^2$ where x_i are point coordinates. The above was mentioned by Weyl with regards to Einstein, although these things were reflected in works by Poincare [Poincare2, Poincare3]. The spirit of relativity theory exists in this fact since everything else can be derived automatically through this including the concept of simultaneity for different points in space using a light signal, and which was undoubtedly contained in papers published by Poincare in years preceding 1905.

From this stage on-wards, we turn our attention to the details of the relativistic mechanics as formulated by Poincare. At the end of this discourse, the reader would have become familiar with the fact that Poincare arrived at the same results as Einstein and hence the erroneous conclusions and notions that one has should be settled once and for all.

* Poincare instigated the concept of four-velocity and used them to compute the relations for the variation of the energy of particle and work done in unit time. We show the calculations here as given by Logunov. Note that because space-time is four dimensional, the physical quantities that are described by the vectors will have four components. We begin with the four vector describing a point-like system which is given by,

$$U^\nu = \frac{dx^\nu}{d\sigma} \tag{69}$$

$d\sigma$ can be written in Galilean coordinates as,

$$(d\sigma)^2 = c^2 dt^2 \left(1 - \frac{v^2}{c^2}\right) \tag{70}$$

Plugging the expression for $d\sigma$ into eq.(50) yields,

$$U^0 = \gamma,\ U^i = \gamma \frac{v^i}{c},\ v^i = \frac{dx^i}{dt}, \quad i = 1,\ 2,\ 3. \tag{71}$$

The four-momentum is given by,

$$P^\nu = mcU^\nu \tag{72}$$

given, m is the rest-mass of the point-like system. Inherently, the equation of relativistic mechanics can be written in the form,

$$mc^2 \frac{dU^\nu}{d\sigma} = F^\nu \tag{73}$$

At this point it is advisable to note that the four-force is orthogonal to the four-velocity, i.e.,

$$F^\nu U_\nu = 0 \tag{74}$$

Now employing equations (51) and (52), eq.(54) can be written as,

$$\frac{d}{dt}\left(\frac{m\vec{v}}{\sqrt{1 - \frac{v^2}{c^2}}}\right) = \vec{F}\sqrt{1 - \frac{v^2}{c^2}} \tag{75}$$

$$\frac{d}{dt}\left(\frac{mc}{\sqrt{1 - \frac{v^2}{c^2}}}\right) = \vec{F^0}\sqrt{1 - \frac{v^2}{c^2}} \tag{76}$$

Invoking the correspondence principle requires that at velocities negligible compared to the speed of light, eq.(56) should harmonize with Newton's equation. Hence $\vec{F}$ can be written as,

$$\vec{F} = \frac{\vec{f}}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{77}$$

where $\vec{f}$ is the force in 3-D space. Now upon verification that eq.(57) is the outcome of eq.(56), it is found that,

$$F^0 = \frac{\left(\frac{\vec{v}}{c}\vec{f}\right)}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{78}$$

Finally, based upon equations (58) and (59), we get the equations of relativistic mechanics as obtained by Poincare as,

$$\frac{d}{dt}\left(\frac{m\vec{v}}{\sqrt{1-\frac{v^2}{c^2}}}\right)=\vec{f} \tag{79}$$

and,

$$\frac{d}{dt}\left(\frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}\right)=\vec{f}\vec{v} \tag{80}$$

* Poincare independently arrived at the mass-energy equivalence formula in [Poincare3]. In [Logunov], the author writes,

> "In § 7 of article [Poincare3] H. Poincare derives equations of relativistic mechanics. If we change the system of units in this paragraph from M = 1, c = 1 to Gaussian system of units, then it is easy to see that inert mass of a body is also determined by formula: $M = \frac{E}{c^2}$. Therefore, it follows from works by H. Poincare that the inert mass both of substance, and of radiation is determined by their energy. All this has been a consequence of the electrodynamics and the relativistic mechanics."

Moreover the paper, in which Einstein arrived at the equivalence of mass-energy, has been criticized by a few scholars on grounds of logical incorrectness. An instance to the aforementioned is given by Max Jammer in his book [Jammer1]. He writes,

> "Usually one says that the theorem of inertia in its full generality has been first established by Einstein in 1905. (Max Born "Atomic physics", Russian translation: Moscow, "Mir", 1965, p. 72), in this relation refers to Einstein article "Does the inertia of a body depend on the energy contained in it?". On the base of the electromagnetic field Maxwell-Hertz equations Einstein states that "if a body gives away energy E in the form of radiation, then its mass decreases by E/c^2".
>
> Generalizing this result onto all energetic transformations Einstein concludes: "The mass of a body is a measure of the energy contained in it". A curious occasion in the history of scientific thinking is the fact that Einstein own derivation of formula $E = mc^2$, as it is given in his article published in "Annalen der Physik" has been logically incorrect. In fact, what is known to non-experts as the most celebrated mathematical formula among all discovered in science (William Cahn "Einstein, a pictorial biography". New York: Citadel, 1955. p. 26), really has been only a result of petiti principia, i.e. an argument based upon a statement which should itself be proved".
>
> ". . . The logical groundlessness of the Einstein deduction was demonstrated by Ives (Journal of the Optical Society of America. 1952. 42. pp. 540-543)".

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* The principle of constancy of the velocity of light is a ramification of Poincare's principle of relativity for all natural phenomena. Quoting [Logunov],

> "It is often written that the principle of constancy of the velocity of light underlies special relativity theory. This is wrong. No principle of constancy of the velocity of light exists as a first physical principle, because this principle is a simple consequence of the Poincare relativity principle for all the nature phenomena. It is enough to apply it to the emission of a spherical electromagnetic wave to get convinced that the velocity of light at any inertial reference system is equal to electrodynamic constant c.
>
> Therefore, owing to its partial role, this proposition, as we already noted, does not underlie relativity theory. Precisely in the same way, the synchronization of clocks at different points of space, also, has a limited sense, since it is possible only in inertial reference systems. One cannot perform transition to accelerated reference systems on the basis of the constancy principle of the velocity of light, because the concept of simultaneity loses sense for them, since the synchronization of clocks at different points in space depends on the synchronization path. The need to describe effects by means of coordinate quantities arises."

The repression of Poincare's works [Poincare2, Poincare3] continued throughout the twentieth century. It was opined that the special theory of relativity is created by A. Einstein alone as can be seen from the detailed analysis by Logunov in his book [Logunov]. However, we were not able to find a single idea or even the groundwork of an idea from the 1905 work by A. Einstein which has not been present in papers by Poincare. We have provided in brief all the necessary discussions and their justification which should settle the matter hereafter. To come to terms with this section, we present a quotation by Nobel laureate Wolfgang Pauli in association with the 50^{th} anniversary of the theory of relativity:

> "Both Einstein and Poincare relied on the preparatory works of H.A. Lorentz, who came very close to the final result, but was not able to make the last decisive step. In the coincidence of the results obtained independently by Einstein and Poincare I see the profound sense of harmony of the mathematical method and analysis, performed with the aid of thought experiments based on the entire set of data from physical experiments".

* Poincare in [Poincare2], derived relativistic formulae for adding velocities and the transformation law for forces. The existence of gravitational waves propagating with light velocity was also predicted in the same manuscript.

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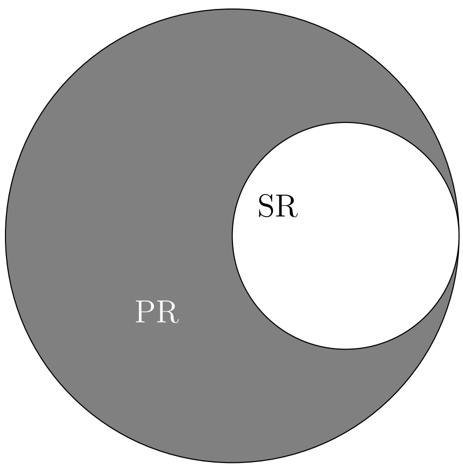
3.1 Poincare Vs Einstein Relativity

In the previous section, some striking evidences were shown in the favour that Henri Poincare independently completed the special theory of relativity. Here we lay certain differences between Poincare Relativity and Einsteinian Relativity and thus show why the former is better suited in our pursuit of physics extensively and most importantly, in our search for a unified theory.

Einstein's grounds of declining aether and remarking it as superfluous was his major drawback. However, Einstein later regretted and believed that the aether might exist after-all. He said with regards to his general theory of relativity that space-time is nothing but the aether. Poincare on the other hand, gets an upper-hand here as he doesn't disregard the aether and also doesn't deny the existence of a special reference frame. Poincare famously quoted [Poincare4], "The space thus created is only a small space that does not extend beyond what my arm can reach". With this he meant that there are things beyond the reach of one's capability, hence if one is not familiar with a particular knowledge doesn't imply that it simply doesn't exist at all. This can be clearly related to the debate over the existence of aether.

Poincare's framework also allows the incorporation of quantum mechanics whereas Einstein's SR is incompatible with a whole lot of quantum phenomena as can be seen in the adjacent section. An overarching perspective is that, there is not a single phenomena that Einstein's SR explains which the Poincare's theory does not. However, there are huge plethora of phenomena that PR explains but SR doesn't for example the unification of physics. It can thus be inferred that Einstein's theory rather than Poincare's, is an ad-hoc. Hence Poincare Relativity is a super-set whose subset is Einstein's SR. Hence there are no novel consequences in Einstein's relativity. The Venn diagram as depicted below clearly summarizes our conclusions.



3.2 Shortcomings of Einsteinian Relativity

Although Einstein's special theory of relativity revolutionized our understanding of the laws of nature, it becomes troublesome in certain situations. In this section we discuss some of those issues and show why they are reasonable arguments.

Special relativity fails in certain quantum mechanical circumstances. Consider the double slit experiment wherein the distance between the slits is increased so large that it approaches infinity. Will the interference fringes still show up? The answer is yes, which although peculiar, is consistent with the mathematical notions. Let us show for an intuitive visualization, the mathematics that goes around in an interference situation. Consider two waves of the form,

$$\Psi_1 = \psi_1(x)\, e^{-iE_1 t/\hbar} \tag{81}$$

and,

$$\Psi_2 = \psi_2(x)\, e^{-iE_2 t/\hbar} \tag{82}$$

Scrutinizing the particle as a probability wave, the superposition would give,

$$\Psi = \Psi_1 + \Psi_2 = c_1\psi_1(x)\, e^{-iE_1 t/\hbar} + c_2\psi_2(x)\, e^{-iE_2 t/\hbar} \tag{83}$$

We have now, for the probability density (given by the Born rule),

$$\Psi^*\Psi = [c_1^*\psi_1^*(x)\, e^{+iE_1 t/\hbar} + c_2^*\psi_2^*(x)\, e^{+iE_2 t/\hbar}][c_1\psi_1(x)\, e^{-iE_1 t/\hbar} + c_2\psi_2(x)\, e^{-iE_2 t/\hbar}] \tag{84}$$

which upon simplification would yield,

$$\begin{aligned}\Psi^*\Psi = c_1^*c_1\psi_1^*(x)\psi_1(x) + c_2^*c_2\psi_2^*(x)\psi_2(x) \\ + c_2^*c_1\psi_2^*(x)\psi_1(x)e^{i(E_2-E_1)t/\hbar} + c_1^*c_2\psi_1^*(x)\psi_2(x)e^{-i(E_2-E_1)t/\hbar}\end{aligned}$$

The above represents the quantum interference phenomena in an explicit manner. This would be true for any slit width because a probability wave is an abstract mathematical disturbance which can extend even up till infinity and which is well known from quantum mechanics. It is only when a measurement is made that the probability density, which predicts where the particle would be found most likely, yields a localized point in space-time and thus the particle can go through the slits and create the interference fringes as usual.

The situation takes a bizarre turn when a conscious observer is introduced. The collapse of the particle's wave state seems to be brought about fundamentally in some way by the observer's consciousness. The wave function collapse process can be dealt mathematically in the following manner: consider a superposition of the form,

$$|\psi\rangle = \sum_{\omega} |\omega\rangle \langle\omega|\psi\rangle \tag{85}$$

where $|\psi\rangle$ is a vector in a Hilbert space $\mathcal{H}$. The measurement of the variable Ω changes the state vector, which in general is some superposition of the form similar to the above equation, into the eigenstate $|\omega\rangle$ corresponding to the eigenvalue ω obtained in the measurement. This can be shown more explicitly as follows: eq. (69) can be viewed as an identity operator, $I = \sum_{\omega} |\omega\rangle \langle\omega|$ in a fixed basis $\{\,|1\rangle\,, |2\rangle\,, ..., |\omega\rangle\,\}$. Therefore,

$$|\psi\rangle = \hat{I}\,|\psi\rangle = \sum_{\omega} |\omega\rangle \langle\omega|\psi\rangle = \sum_{\omega} (\langle\omega|\psi\rangle)\,|\omega\rangle = \sum_{\omega} a_{\omega}\,|\omega\rangle \tag{86}$$

The collapse can simply be represented as, $\sum_{\omega} a_{\omega}\,|\omega\rangle \longrightarrow |\omega\rangle$ and the normalized wave function is given by,

$$\langle\psi|\psi\rangle = \sum_{\omega} |a_{\omega}|^2 = 1 \tag{87}$$

The whole point is that consciousness causes wave function collapse is an instantaneous/simultaneous event, i.e. faster than the speed of light. The collapse process can be seen more explicitly by the fact that the wave function collapses even before the light ray enters into the pupil of the observer, implying a "delay" of information between neurological measurement and registering of the wave function collapse. Hence two ontologies gets mapped onto each other through some tranformation equations, if they can be considered to be a part of a larger manifold, if it can be called that. Therefore, one can't pre-suppose consciousness, i.e. it can't be viewed from a reductionist point of view since it is known that consciousness is non-computational and it has its ontological reality [9 cite Penrose]. It is as real as anything else and its existence can't be questioned given the situation discussed above. An analogy can be drawn here to Rene Descartes "Cogito Ergosum" [10]. Hence, SR axioms fall short when certain quantum mechanical situations emerge. Consider another example with regard to the above discussion. Let there be a string of a considerable length say l. Now if it is sliced into a stack of small sheets each of length $d\,l$, all the slices would collapse only in a single continuos sheet, considering the fact that the von Neumann chain is correct. The chain can be summed up schematically in a rich way using the Knight's equation given by [cite Knight],

$$|O\rangle\,(|M_o\rangle\,|F_o\rangle\,|W_o\rangle) = (|A\rangle + |B\rangle)\,(|M_o\rangle\,|F_o\rangle\,|W_o\rangle) \xrightarrow{t_1} \tag{88}$$

$$(|A\rangle\,|M_A\rangle + |B\rangle\,|M_B\rangle)\,(|F_o\rangle\,|W_o\rangle) \xrightarrow{t_2} \tag{89}$$

$$(|A\rangle\,|M_A\rangle\,|F_A\rangle + |B\rangle\,|M_B\rangle\,|F_B\rangle)\,(|W_o\rangle) \xrightarrow{t_3} \tag{90}$$

$$(|A\rangle\,|M_A\rangle\,|F_A\rangle\,|W_A\rangle + |B\rangle\,|M_B\rangle\,|F_B\rangle\,|W_B\rangle) \tag{91}$$

This substantiates our discussion above and reveals that our neurology only acts as a measuring device and makes precise measurements in the metric frame. However, consciousness is something which transcends the neurology as a whole and acts as a true observer beyond space-time.

Another counterexample to the conjecture that nothing can travel faster than the speed of light can be seen in neuroscience. Since consciousness exists, let us suppose that we visit past (in our mind) greater than the speed of light, therefore accessing the memories are not bounded by the ontological speed of light. If we try to recall about past memories they are retrieved within a fraction of second which is almost instantaneous. The mechanism can be understood as follows, neurons in the brain fire in metric frame and are related to Lorentz transformations considering transition to non-metric frame, which is the frame in which the consciousness supposedly exists. The physical neurological signals generated, accesses through electrical signals moving with the speed of light. However, since consciousness is not bounded, in light cone and in linearity, hence one can't capture an unbounded thing from bounded means. This clearly undermines Einstein's relativity theory and renders it incomplete [11 cite Godel].

Other examples that violate Einstein's notion about impossibility of faster than light travel include the proposal of tachyons and the expanding universe [12-15]. Tachyons, if they exist, should be considered in a non-metric frame since if we assume the proposition that their velocity is greater than that of light, it automatically indicates that they have transcended the metric frame. Their existence is thus itself a proof of a special reference frame. The expansion of the observable universe is also a matter of great debate in modern physics and cosmology. The observational constraints show that the expansion is accelerating and conceivably, faster than the speed of light [16, 17].

Thus if we take SR axioms and consider them a priori correct, although they would be valid in special case but if we take universe as a whole and for that matter reality as a whole, SR fails miserably. Thus Einstein's premises fall short and require significant revision.

4 Michelson-Morley Experiment

In late nineteenth century, a very classic experiment was conducted aimed at detecting the motion of the earth relative to the so called "Aether" [MM1]. However the experiment was loaded with several inadequacies and faulty interpretations. In this section we look at some of the very famous counter-arguments and present them in the form of quotations.

We begin with the contents from a very famous book by William Lane Craig [WL-Craig1],

> "Michelson carried out his experiment for the first time in 1881, but his results

were vitiated by various errors and oversights. Then in 1887 with the cooperation of E. W. Morley, he conducted one of the most famous experiments in the history of science, the Michelson-Morley measurement of the earth's motion through the aether. They mounted the interferometer on a marble slab and floated the slab on mercury so that it could be smoothly rotated around a central pin. Mirrors were arranged to reflect the light beams back and forth through eight round trips, thus making the total distance traveled 11 meters and thereby increasing the accuracy of their measurements.

To Michelson's chagrin, the experiment, contrary to expectation, yielded no significant change in the interference fringes whatsoever. Taken literally, what the results seemed to indicate was that the earth was perfectly at rest in the aether! But that seemed clearly impossible: for even if, by some extravagant coincidence, the motion of the earth in its orbit in one direction were exactly counterbalanced by, say, the motion of the solar system in the opposite direction, so that the earth's net motion through the aether was precisely zero, still the earth was itself rotating and yet the readings of the interferometer were constant whether recorded day or night. Moreover, readings taken at different times of the year, for example, six months apart, when the earth is moving in its orbit in exactly opposite directions, remained invariant. Earth could not be at rest in the aether. So why was its motion undetectable?"

"Thus, the reason the Michelson-Morley experiment failed to detect any change in the interference fringes was because whichever arm of the interferometer was parallel to the direction of motion was contracted by a factor of $\sqrt{1-v^2/c^2}$."

"According to Holton, "In reading Lorentz's book of 1895, Einstein will have found that the [Michelson-Morley] experiment was not thought to be the crucial event upon which a new physics must be built: it was only one of several second order experiments that at the time could be explained only by invoking yet another unhappy ad hoc hypothesis to all the others on which current theory was built." However, correspondence from around the turn of the century between Einstein and his fiancee Mileva Maric which has come to light since Holton's essay suggests that Holton underestimated the role which the Michelson-Morley experiment and others like it played in the development of Einstein's thinking. From his correspondence with Maric between 1899 and 1901 we learn that Einstein was enthusiastically preoccupied with experimental attempts to measure the earth's velocity relative to the aether.

In his letter of September 1899, he mentions reading "a very interesting paper" by Wilhelm Wien of Aachen. In this paper Wien reviews the Michelson-

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> Morley experiment and also mentions the contraction hypothesis as an attempted explanation of its null result. In September of 1901 Einstein wrote a latter to Marcel Grossmann, in which he refers to the "customary interference experiments" to measure the motion of matter relative to the aether. Writing to Marie in December of that year, Einstein enthusiastically revealed his own plans to design experiments aimed at measuring the Earth's velocity relative to the aether and mentioned his intention to read Lorentz's work. He said that he was on the verge of publishing a "capital paper" on relative motion and electrodynamics-but, as we know, nothing appeared for the next three and a half years.
>
> Surveying this new evidence, John Stachel concludes, "He was very much interested in ether drift experiments and appears to have designed at least two, which he hoped to carry out himself ... .ideas about ether drift experiments did form an important strand in his thinking about the complex of problems that ultimately led him to develop the special theory of relativity." Rather than embrace a theory which struck him as ad hoc and artificial, Einstein preferred to abandon altogether what he later called a "constructive" approach (such as Lorentz's) to a satisfactory theory and instead to cut the feet out from under the difficulties in classical physics by proposing fundamental revisions of our concepts of space and time so that such problems could not even arise."

Famous physicist and nobel laureate Paul Dirac wrote in 1951 [cite],

> "Physical knowledge has advanced much since 1905, notably by the arrival of quantum mechanics, and the situation (about the scientific possibility of aether) has again changed. If one examines the question in the light of present-day knowledge, one finds that the aether is no longer ruled out by relativity, and good reasons can now be advanced for postulating an aether...We have now the velocity at all points of space-time, playing a fundamental part in electrodynamics. It is natural to regard it as the velocity of some real physical thing. Thus with the new theory of electrodynamics (vacuum filled with virtual particles) we are rather forced to have an aether".

John Bell in 1986, interviewed by Paul Davies in "The Ghost in the Atom" has suggested that an Aether theory might help resolve the EPR paradox by allowing a reference frame in which signals go faster than light. He suggests Lorentz contraction is perfectly coherent, not inconsistent with relativity, and could produce an aether theory perfectly consistent with the Michelson–Morley experiment. Bell suggests the aether was wrongly rejected on purely philosophical grounds: "what is un-observable does not exist" [p. 49]. Einstein found the non-aether theory simpler and more elegant, but Bell suggests that doesn't rule it out. Besides the arguments based on his interpretation of quantum mechanics, Bell also suggests resurrecting the aether because it is a useful pedagogical device. That is, many problems are solved more easily by imagining the existence of an aether.

Now we present refutations of the Michelson-Morley experiment from a very scholarly discussion by experts on a premier platform [Researchgate].

> "Ether, if existed, it should be like a fluid, in order to permit all the dynamics of the universe. And Michelson Morley's experiment cannot defeat it, because the fluid ether will move along with the earth, like the atmosphere moving with the earth, so there will not be relative motion between the earth and the ether on the surface of the earth. Ether, if exists, would stand still in the parts of the universe where there is no moving objects, but because of its fluidity, it would move along with the objects when it is near them and it can be stirred and can flow like a fluid." [Hüseyin Göksu, Akdeniz University]

> "It is a common misconception that the MMX disproved any aether, what it proved was only that, if there was an aether, it had to be Lorentz Invariant." [George Dishman, Thales Group UK]

> "The M,M experiment is generally thought to disprove the (Lorentz) aether. And the Einstein's Special relativity seemed to remove the need for it. But Lorentz with the aid of Poincaré produced a modification of the Lorentz theory (containing an aether) which actually was submitted for publication before Special Relativity came out. But SR appeared in publication before the Lorentz-Poincaré paper appeared. So the L-P paper (though in complete agreement with SR) was largely ignored. Interestingly, in his later life, Einstein himself suggested that one should look again at the idea of an aether." [Carl Frederick Ph.D., Central Research Group]

> "It is my understanding that Einstein's Special Relativity is based on the Lorentz transformation. And the Lorentz transformation was invented to explain the null results of the Michelson-Morley experiment. And the Lorentz transformation is based on the postulates that there is a universal ether that behaves like an ideal frictionless incompressible fluid that the earth flows through without interacting. The mainstream and even most that question Einstein's Relativity are fixated on this model.
>
> He further goes on to say,
>
> My opinion is that we need a "paradigm shift" and that this alternative ether model could be the answer. As Thierry De Mees points out: "Hence, many possibilities remain open w.r.t. aether, and an aether as you imagine it,

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connected to the gravity potential, is perfectly complying with Michelson's experiment." Based on the Beckmann/Su models, I (and others) predict that a Michelson-Morley type experiment performed in low earth orbit would have a positive result equivalent to the orbital velocity of the spacecraft (about 7.5 km/sec). This would be very persuasive evidence that there is an ether carried with the earth that is stationary with respect to the Earth Centered Inertial Frame (the ECI) and that Special Relativity is invalid." [James Marsen, Alumnus: Columbia University]

"The experiment was a very idiotic experiment. It was like a fisherman using nets to catch wind in the ocean. It assumed that Ether was a Mechanistic One Dimensional Drift, always aligning against the motion of the earth and the instrument. Ether is not a mechanistic thing. Subtle can't be captured by the gross!" [Sunil K Srivastava, Alumnus: Indian Institute of Technology Kharagpur]

"My answer is that it actually can provide strong evidence that there is an ether if it is conducted in outer space. There are many explanations for the "null" results of experiments of Michelson-Morley type experiments (MMX). One plausible, but rarely considered, explanation is: there is a small velocity to be measured (360 m/s) but MMX type experiments have simply not been sensitive enough to unambiguously detect it.

The physics community (including "dissidents") almost unanimously assume that if there is an ether, it is universal. And the velocity of a terrestrial lab with respect to this ether model should be at least the Earth's orbital velocity of 30,000 meters/second. The detection of a Doppler effect in the CMB has led some to assume that the velocity should be 10 times higher at 368,000 m/s and toward 11hr, Right Ascension, 6° Declination. However, there is experimental evidence from first order in v/c phenomena such as the GPS pseudo-range correction (also called the Sagnac correction) that there is a non-zero but much lower velocity than commonly expected. These phenomena indicate that the velocity is actually the Earth's rotation velocity with respect to the Earth Centered Inertial reference frame (the ECI) at the location of the experiment: 465 cos(θ) meters/sec where θ is the location's latitude (e.g. 365 m/s at 40°).

Two-way Intercontinental microwave links also support this interpretation. This velocity is too low for MMX type experiments prior to the 1979 Brillet and Hall experiment to detect because Michelson type interferometers are second order in v^2/c^2. A few have analyzed this experiment and concluded

> that a signal at twice the rotation rate of the interferometer was present and it was the right order of magnitude for the Earth's rotation velocity. However this signal was dismissed as "spurious" and averaged out of the results.
>
> I suggest this was partially because the signal was too weak to unambiguously distinguish from noise; partially because they were looking for something else: Lorentz Invariance violations with respect to the CMB dipole; and partially because they were so confident that Einstein's Relativity is correct that they assumed it couldn't be a real signal.
>
> Other more sensitive MMX type experiments conducted in the past two decades with cavity resonators have also dismissed a signal at twice the rotation rate of the interferometer platform (which is consistent with the Earth's rotation velocity) as essentially noise. So the best way to unambiguously detect a velocity with respect to the ECI is to increase the velocity of the interferometer with respect to the ECI. This can be done by launching the experiment into low Earth orbit where its velocity with respect to the ECI will be its orbital velocity. The velocity of a spacecraft in an orbit with a 500 km altitude is 7600 meters/sec. This is 7600/365 = 21 times faster for a 212 = 440 times larger (and easier to detect) fringe shift/frequency variation.
>
> If launched into an interplanetary orbit, it should be even easier to detect its velocity with respect to the Barycenter Inertial reference frame (also known as the Sun Centered Inertial reference frame (30,000 m/s). If such an experiment is conducted and reports a positive result, then the foundational concept that the speed of light is independent of the motion of the receiver with respect to any reference frame will be falsified. Since Special Relativity is derived from this concept and General Relativity is built on the foundation of Special Relativity they will also be falsified." [James Marsen, Alumnus: Columbia University]

We have found some significant literature on the re-analysis of the Michelson-Morley experiment and would present some thoughts from the same. In [Cahill and Kitto] the authors wrote,

> "However the old Michelson-Morley interferometer experiment is actually a quantum interferometer, that is, in principle it could be done with one photon at a time, and we inquired why it is believed that it was unable to detect a preferred frame, and so absolute motion. In fact it can do so."

> "...Michelson designed the interferometer with the idea that any motion through absolute space (then called the luminiferous aether) would result in different

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> path lengths for light waves in the two arms, which would show as a shift in the fringe. Of course as an experimental expediency one rotates the apparatus through 90^o so that the roles of the two arms are interchanged, this rotation then should result in a shift of the fringes, which is an effect more easily observed. However Michelson and Morley reported a null result, despite a small effect actually being seen.
>
> Fitzgerald and then Lorentz then offered an explanation for the null result, namely that the failure to get an effect was caused by the actual contraction of the arm moving lengthwise through the absolute space, as we show below. However long ago it was decided by physicists that the more elaborate Einstein explanation in terms of spacetime transformations was superior to this dynamical explanation.
>
> In reviewing the operation of the Michelson-Morley interferometer (see below) it was noticed that the Fitzgerald-Lorentz contraction explanation only implies a null effect if the experiment is performed in vacuum. In air, in which photons travel slightly slower than in vacuum, there should be a small fringe shift effect when the apparatus is rotated, even after taking account of the Fitzgerald-Lorentz contraction. This appears to have gone unnoticed. As well Munera [cite Munera] in 1998 has corrected the original results for various systematic errors, and shown that these interferometer experiments do indeed reveal small but significant non-null results, but as expected now, only when they are operated in a dielectric."

Now in [Israel Perez], the author writes,

> "In 1887 A. Michelson and E. Morley took the enterprise of carrying out an interferometric experiment to detect this motion by means of a fringe shift. Using ordinary kinematics they thought that a considerable fringe shift would have revealed the existence of the light medium. However, the experimental outcome was almost null in disagreement with the calculations. Consequently, the experiment has been considered (among other similar experiments) as a clear proof of the non-existence of the aether and the isotropy of the speed of light for all inertial observers. Nevertheless, under a new vision, we shall explain that a null result must be assumed, on one hand, only for purposes of theorization and, on the other, to expose the inconsistency between ordinary electrodynamics and Galilean relativity (GR), from which does not follow that there is no light medium."

> "...the aether as physical reality is not matter of metaphysics but of logic. As a science, physics must be coherent not only mathematically but also

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> physically. And nature is telling us so emphatically that all classical waves require a material medium. But when we refused the aether we not only deprived the universe of a privileged frame but also of mass. Instead, the Maxwellian aether was replaced by the gravitational aether (four-dimensional space-time) which obviously lacks the whole mass of the original one since the stress-energy tensor can only account for the mass of baryonic matter, leptons, gravitational binding energy and radiation. Then, if there is no aether, this rises the question: where do dark matter come from?"

In [Fedi1], a unified theory of superfluid origin has been proposed. In the same paper, the author has criticized the traditional approach of the Michelson-Morley experiment and has addressed it as ill-suited, particularly for his formalism and has thus suggested a modification to fetch positive results. He writes,

> "Indeed, in our case the original premise of the Michelson-Morley test was wrong, since the ether (dark energy) is not stationary but radially directed toward the center of the Earth, independently of its motion about the Sun. The only influence on this flow may come from a celestial body's rotation and corresponds to the Lense-Thirring precession described in general relativity, in which the rotation of the body bends the gravitational field (Fig. 15). Tests with a vertically placed Michelson interferometer gave positive result, analogous experiences should be therefore repeated and confirmed."

In another paper, following has been mentioned by the authors in their conclusions [Klaus Wilhelm and Bhola N. Dwivedi],

> "An aether concept – required by GTR (Einstein 1924) – is not inconsistent with STR, and allows us to interpret the photon processes on the basis of momentum and energy conservation."

In yet another paper, Cahill argues that Michelson-Morley didn't get the actual interpretation of their own results. He writes in conclusions [Cahill2],

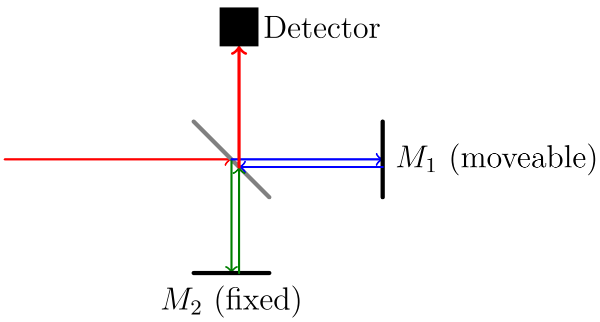
> "So absolute motion was first detected in 1887, and again in at least another six experiments over the last 100 years. Had Michelson and Morley been as astute as their younger colleague Miller, and had been more careful in reporting their non-null data, the history of physics over the last 100 years would have totally different, and the spacetime ontology would never have been introduced.
>
> That ontology was only mandated by the mistaken belief that absolute motion had not been detected. By the time Miller had sorted out that bungle, the world of physics had adopted the spacetime ontology as a model of reality

because that model appeared to be confirmed by many relativistic phenomena, mainly from particle physics, although these phenomena could equally well have been understood using the Lorentzian interpretation which involved no spacetime. We should now understand that in quantum field theory a mathematical spacetime encodes absolute motion effects upon the elementary particle systems, but that there exists a physically observable foliation of that spacetime into a geometrical model of time and a separate geometrical model of 3-space."

Upon reading the contents of this section, the reader should have got acquainted with the erroneous foundations of the Michelson-Morley experiment. We believe that there shouldn't remain henceforth, any margin of error in the reader's mind related to this. Thus we can conclude the section with a pun intended yet overriding statement that, Michelson-Morley's paper was its own refutation.

4.1 True form of Michelson-Morley experiment

In this module, we look at the ideal form of the Michelson-Morley experiment. In other words, we look at the implications of having a near-perfect interferometer aimed at making measurements which the classic Michelson-Morley experiment was actually seeking in the first place.



The above figure is a basic schematic of the Michelson interferometer, which was invented by A.A. Michelson and subsequently employed in the experiment in collaboration with E. Morley and which aimed at detecting the aether [cite XJ Tian]. Below, we have shown another figure of the LIGO interferometer which is nothing but a scaled-up version of the Michelson interferometer [Image: Caltech/MIT/LIGO Lab.]. As is known to all that the LIGO detected the gravitational waves which are ripples in the fabric of spcae-time [LIGO1]. At this point we remember Albert Einstein's remark that he made around the 1920s, "We may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an Aether."

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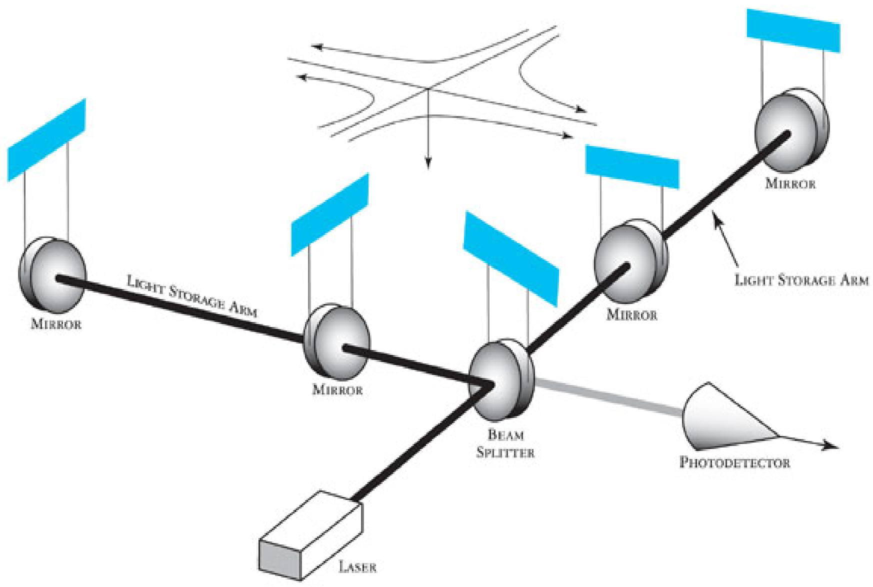

Thus LIGO being an advanced version of the Michelson interferometer and Einstein making the remark that space-time is aether leads us to the natural claim that the LIGO has detected the aether itself or "aethereal waves" to be precise.

One may argue that if gravitational waves are same as aethereal waves, then what is the point of discussing the same. According to a certain view, it should not matter if a thing is called by one name or the other. However the problem here is interpretational. The old aether concept which had been discarded has to be re-incorporated and the detection by LIGO should act as the most promising reason to do the same.

5 Cube model

In this section we introduce a certain phenomenological model which might describe the quantization of gravity.

Consider the entire universe to be contained inside a gigantic cube. Let the cube explode in a manner similar to the case of the big bang model. If we assume a priori that the universe originated in close approximation as described by the big bang theory, then the explosion of the cube would release a huge amount of "fluid" which in other words can be referred to as dark energy itself. The fluid by its very own nature would create ripples in the fabric of space-time. If the cube is further viewed as being made from simpler cubes, it would clearly signify the transition from a discrete behaviour to a continuous behavior. Since the source itself is a representation of discrete to continuous transition, the resultant or the products also have this inherent property.

The simpler cubes as discrete objects create the big cube if placed in an orderly fashion. This discrete cube is nothing but the basic unit of space-time itself. If we consider space-time to be the aether, the discrete cube is the "quantized aether" which

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is also the long sought tensor boson of the standard model, the graviton. Similar model of the discrete cube has been conceptualized by a team of scientists in Los Angeles [cite QGR], in which they view it as a “quasicrystal”.

Quantum fluctuations in the aether can yield the various particles of the standard model, with each unique particle emerging at a particular energy and frequency of vibration in the aether. This is synchronous to the string-theoretic approach as well [cite string theory].

It is well known that field theories are nothing but continuum mechanics. Let us imagine a fluid filling space-time and consider a free scalar field which can be described by the Lagrangian [Guth lecture notes],

$$L = \int d^3x\, \mathcal{L} \tag{92}$$

where,

$$\mathcal{L} = \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{1}{2}m^2\phi^2 = \frac{1}{2}\dot{\phi}^2 - \frac{1}{2}\nabla_i\phi\nabla_i\phi - \frac{1}{2}m^2\phi^2 \tag{93}$$

Let us now imagine replacing the continuos space by a cubic lattice of closely spaced grid points, with a lattice spacing a, and we can constrain the space to a finite region. The system then reduces to one with a discrete number of dynamical variables, exactly like the systems that we already know how to quantize. Then if we can take the limit as the lattice spacing a approaches zero and the volume approaches infinity, the quantization of the field theory can be completed. When we replace the continuous space by a finite lattice of points, we can label each lattice site with an index k. In a fully detailed lattice description we would probably label each lattice site with a triplet of integers representing the x, y, and z coordinates of the site, but for present purposes it will suffice to imagine simply numbering all the lattice sites from 1 to N, where N is the total number of sites. The field $\phi(\vec{x}, t)$ is then replaced by a set of dynamical variables $\phi_k(t)$, where one can think of $\phi_k(t)$ as representing the average value of $\phi(\vec{x}, t)$ in a cube of size a surrounding the lattice site k. The Lagrangian as described earlier is then replaced by

$$L = \sum_k \mathcal{L}_k \Delta V \tag{94}$$

where,

$$\Delta V = a^3 \tag{95}$$

and

$$\mathcal{L}_k = \frac{1}{2}\dot{\phi}_k^2 - \frac{1}{2}\nabla_i\phi_k\nabla_i\phi_k - \frac{1}{2}m^2\phi_k^2 \tag{96}$$

Here the lattice derivative $\nabla_i \phi_k$ is defined by,

$$\nabla_i \phi_k \equiv \frac{\phi_{k'(k,i)} - \phi_k}{a} \tag{97}$$

where $k'(k,i)$ denotes the lattice site that is a distance a in the i^{th} direction from the lattice site k. The canonical momenta are then given by,

$$p_k = \frac{\partial L}{\partial \dot{\phi}_k} = \frac{\partial \mathcal{L}_k}{\partial \dot{\phi}_k} \Delta V = \dot{\phi}_k \Delta V \tag{98}$$

Since the canonical momenta are proportional to ΔV , it is natural to define a canonical momentum density π_k by

$$\pi_k \equiv \frac{p_k}{\Delta V} = \frac{\partial \mathcal{L}_k}{\partial \dot{\phi}_k} = \dot{\phi}_k \tag{99}$$

Let us define the Hamiltonian as,

$$H = \sum_i p_i \dot{q}_i - L \tag{100}$$

Following our considerations, the Hamiltonian is modified as,

$$H = \sum_k p_k \dot{\phi}_k - L = \sum_k \left[\pi_k \dot{\phi}_k - \mathcal{L}_k \right] \Delta V \tag{101}$$

The canonical commutation relations become,

$$[\phi_{k'}, \phi_k] = 0, \; [p_{k'}, p_k] = 0, \; and \; [\phi_{k'}, p_k] = i\hbar \delta_{k'k} \tag{102}$$

In terms of the canonical momentum densities,

$$[\phi_{k'}, \phi_k] = 0, \; [\pi_{k'}, \pi_k] = 0, \; and \; [\phi_{k'}, \pi_k] = \frac{i\hbar \delta_{k'k}}{\Delta V} \tag{103}$$

The continuum canonical momentum density becomes,

$$\pi(\vec{x}, t) = \frac{\partial \mathcal{L}}{\partial \dot{\phi}(\vec{x}, t)} = \dot{\phi}(\vec{x}, t) \tag{104}$$

and the Hamiltonian becomes,

$$H = \int d^3x \left[\pi \dot{\phi} - \mathcal{L} \right] \tag{105}$$

The trivial canonical commutation relations carry over trivially:

$$[\phi(\vec{x}', t), \phi(\vec{x}, t)] = 0 \; and \; [\pi(\vec{x}', t), \pi(\vec{x}, t)] = 0 \tag{106}$$

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obviously. For the nontrivial commutation relation, the result will be clearest if we first rewrite the last equation in (94) as a sum which will become an integral in the limit. If we let $\mathcal{R}$ denote a region of the lattice, the last equation in (94) becomes,

$$\sum_{k \epsilon \mathcal{R}} \Delta V = i\hbar \sum_{k \epsilon \mathcal{R}} \delta_{k'k} = i\hbar \begin{cases} 1 & if\ k' \epsilon\, \mathcal{R} \\ 0 & otherwise. \end{cases} \tag{107}$$

In the continuum limit,

$$\sum_{k \epsilon \mathcal{R}} [\phi_{k'}, \pi_k] \Delta V \tag{108}$$

clearly approaches,

$$\int_{\vec{x} \epsilon \mathcal{R}} d^3x [\phi(\vec{x}', t), \pi(\vec{x}, t)] \tag{109}$$

so Eq.(98) becomes,

$$\int_{\vec{x} \epsilon \mathcal{R}} d^3x [\phi(\vec{x}', t), \pi(\vec{x}, t)] = i\hbar \begin{cases} 1 & if\ \vec{x}' \epsilon\, \mathcal{R} \\ 0 & otherwise. \end{cases} \tag{110}$$

This relationship can be expressed more conveniently by introducing the Dirac delta-function $\delta^3(\vec{x})$, which is defined by its integral,

$$\int_{\vec{x} \epsilon \mathcal{R}} d^3x\, f(\vec{x})\, \delta(\vec{x} - \vec{x}') \equiv \begin{cases} f(\vec{x}) & if\ x' \epsilon\, \mathcal{R} \\ 0 & otherwise. \end{cases} \tag{111}$$

Given this definition, Eq.(101) can be rewritten as,

$$[\phi(\vec{x}', t), \pi(\vec{x}, t)] = i\hbar\, \delta(\vec{x} - \vec{x}') \tag{112}$$

Note that the delta function is symmetric, so, $\delta(\vec{x} - \vec{x}') = \delta(\vec{x}' - \vec{x})$.

The cube model as described here can be also be approximated to a shell model of the universe as described by Alan Guth and which we are going to illustrate here now. In the shell picture, matter at time t_i can be divided into concentric shells where each shell extends from r_i to $r_i + dr_i$. This cluster of matter particles can be approximated to a collection of dust particles or more specifically a fluid which then relates perfectly to the cube model as conceptualized in our framework. All the motion inside this shell is radial and no tangential forces are acting on the same. Let us define $r(r_i, t)$ as the radius at time t of the shell that was at r_i at time t_i. We can also determine the time evolution of the same and also show that the entire process preserves uniformity and would be in accordance with the Newtonian evolution. All the shells inside the sphere are expanding and moving apart from each other, however, there is also the possibility of two shells crossing each other but that wouldn't be an issue as it would be addressed satisfactorily

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by the model. If the shells crossed each other, then different amount of mass would be acting on different shells. Hence we are going to write down the equations that hold as long as there are no shell crossings. Shell at time r_i feel force of mass inside given by,

$$M(r_i) = \frac{4\pi}{3} r_i^3 \rho_i \tag{113}$$

$$\vec{g} = -\frac{GM(r_i)}{r^2(r_i,t)}\hat{r} \tag{114}$$

$$\ddot{r} = -\frac{4\pi}{3}\frac{Gr_i^3\rho_i}{r^2},\ r \equiv r(r_i,t) \tag{115}$$

Eq.(84) tells us that if all the masses are arranged spherically symmetrically, the force due to mass that's on a shell that has a larger radius than u_r produces no acceleration for u. The only acceleration that u feels is due to the mass at smaller radii. And then taking into account how r changes with time, leads us to eq.(85) which gives the acceleration. Now the equation being a second order differential equation and for it to have a unique solution we need to define the initial conditions for the same and the same is given by,

$$r(r_i,t_i) = r_i \tag{116}$$

$$\dot{r}(r_i,t_i) = H_i r_i \tag{117}$$

Now the essential feature here is that r_i can be made to disappear by:

$$u(r_i,t) = \frac{r(r_i,t_i)}{r_i} \tag{118}$$

$$\ddot{u} = \frac{\ddot{r}}{r_i} = -\frac{4\pi}{3}\frac{Gr_i^3\rho_i}{r_i r^2} = -\frac{4\pi}{3}\frac{Gr_i^3\rho_i}{u^2 r_i^3} = -\frac{4\pi}{3}\frac{G\rho_i}{u^2} \tag{119}$$

$$u(r_i,t) = \frac{r_i}{r_i} = 1 \tag{120}$$

$$\dot{u}(r_i,t) = H_i \tag{121}$$

$$u(r_i,t) = u(t) = a(t) \tag{122}$$

$$r(r_i,t) = a(t)\, r_i \tag{123}$$

The L.H.S. in eq.(93) represents the physical distance from the origin and R.H.S. is the product of scale factor and coordinate distance.

$$\rho(t) = \frac{M(r_i)}{\frac{4\pi}{3}r^3} = \frac{\frac{4\pi}{3}r_i^3\rho_i}{\frac{4\pi}{3}a_i^3 r_i^3} = \frac{\rho_i}{a^3} \tag{124}$$

$$\ddot{a} = -\frac{4\pi}{3}\frac{G\rho_i}{a^2}\frac{a}{a} \tag{125}$$

$$\ddot{a} = -\frac{4\pi}{3} G\rho(t)\, a \tag{126}$$

Eq.(96) gives the deceleration of our model universe in terms of the current mass-density and which also importantly is the second one of the Friedmann equations. The first one is given by,

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi}{3} G\rho - \frac{kc^2}{a^2} \tag{127}$$

Thus we are left with the final equation for the shell model which describes a homogeneous and isotropic universe and which also is the implication of our cube model. Now it is important to note here that any 3D homogeneous and isotropic space can be described by the Robertson-Walker metric given by,

$$ds^2 = a^2(t) \left\{ \frac{dr^2}{1 - \kappa r^2} + r^2 (d\theta^2 + sin^2\theta d\phi^2) \right\} \tag{128}$$

In our model, space-time is treated completely as a fluid or specifically the “aether”. Although the notion of space-time has been replaced with the aether, the dynamics of objects is in complete correlation with the basic principles of general relativity. For instance the geodesics of any particle in a particular metric would be same as that given by GR. The geodesic equation assumes the form,

$$\frac{d^2x^i}{ds^2} = -\Gamma^i_{jk} \frac{dx^j}{ds} \frac{dx^k}{ds} \tag{129}$$

where,

$$\Gamma^i_{jk} = \frac{1}{2} g^{il} (\partial_j \, g_{lk} + \partial_k \, g_{lj} - \partial_l \, g_{jk}) \tag{130}$$

is called the affine connection or the Levi-Civita connection.

In recent years there have been so much progress with new discoveries in string theory and quantum field theories. One such theory which unites gravitational physics on a spacetime with quantum mechanics on its boundary, called the gauge/gravity duality or the AdS/CFT correspondence [cite Maldacena]. This major breakthrough finds its applications in both the large and small domains of functionality. Finding motivation within the AdS/CFT correspondence, Shiraz Minwalla et. al. have proposed the fluid/gravity correspondence [cite Minwalla, Hubeny]. It can be described as a long wavelength limit of Einstein's equations with a negative cosmological constantin $d+1$ dimensions. In such a limit, Einstein's equations narrow down to the equations of fluid dynamics (relativistic generalizations of the famous Navier-Stokes equations) in d dimensions. Conceivably, the most important feature of the fluid/gravity correspondence is the fact that the horizon dynamics (which in this case prescribes the dynamics of the entire space-time) is governed by Hydrodynamics. Quoting from their paper, ”For several decades relativists have explored the idea that space-time or important aspects thereof like black hole hori-

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zons might resemble a fluid. For instance- the Black Hole Membrane Paradigm which states that for external observers, black holes behave much like a fluid membrane, loaded with physical properties such as viscosity, conductivity and so on. In particular, the dynamics of the membrane is governed by the familiar laws of fluid dynamics, namely the compressible Navier-Stokes equations.

Many physicists believe that the universe fundamentally behaves as a fluid and a lot of papers have been written along those lines. One such paper conceives the idea that space-time appears to be a highly viscous liquid [cite Liquid Spacetime (Aether), viscosity, A way to unify physics]. It also uses the Maupertuis/Fermat principle to validate the existence of the aether.

In [cite General Relativity as an aether theory], the authors derive Einstein's equations using Lorentz and Kelvin's conception of an aether. The derivation equates the Ricci tensor to the sum of the usual stress-energy tensor and a stress-energy tensor for the aether which is nothing but a tensor based on Kelvin's aether theory. They have concluded that general relativity follows only from a very special aether theory. A proof has also been presented in the same stating that Einstein gravity equations are a special case of the Newtonian gravity equations coupled to a luminiferous aether.

5.1 Vacuum energy and the aether

In the cube model we have assumed a cube whose length is equal to the Planck length and which can be replaced with the concept of a quasicrystal as well. This description is an attempt to model the scenario of the origin of the universe. Various other concepts such as inflation is also possibly coherent with this picture. One of the main challenges that occurs in modern cosmology is the concept of vacuum energy. No one has a good approximation to what this could possibly be and what is the exact mechanism through which particles can arise through "nothingness". Although according to the laws of quantum mechanics one can possibly argue that the uncertainty principle, a fundamental idea resulting out of quantum mechanics, allows the creation of particles out of vacuum through quantum fluctuations, still it is not very clear as to how the entire picture fits our understanding.

Cosmologists today argue that vacuum energy and cosmological constant are the same things. These two can be related as,

$$u_{vac} = \rho_{vac}c^2 = \frac{\Lambda c^4}{8\pi G} \tag{131}$$

Now the above can also be used to derive the Friedmann equation containing the vacuum energy terms. Let,

$$\dot{\rho_{vac}} = 0 \implies p_{vac} = -\rho_{vac}c^2 = -\frac{\Lambda c^4}{8\pi G} \tag{132}$$

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Now defining,

$$\rho = \rho_{normal} + \rho_{vac} \tag{133}$$

$$p = p_{normal} + p_{vac} \tag{134}$$

$$\frac{d^2a}{dt^2} = -\frac{4\pi}{3}G\left(\rho_{normal} + \frac{3p_{normal}}{c^2} - 2\rho_{vac}\right)a \tag{135}$$

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi}{3}G\left(\rho_{normal} + \rho_{vac}\right) - \frac{kc^2}{a^2} \tag{136}$$

The final equation is the required Friedmann equation.

In [cite Afshordi1], Afshordi addresses the cosmological constant problem and argues that the most straightforward and elegant approach to decouple gravity consistently from the vacuum energy and solve the problem is through the introduction of an incompressible gravitational aether fluid. A simple perfect fluid is hypothesized with a established equation of state w' such that,

$$(8\pi G')^{-}1G_{\mu\nu}[g_{\mu\nu}] = T_{\mu\nu} - \frac{1}{4}Tg_{\mu\nu} + T'_{\mu\nu} \tag{137}$$

where,

$$T'_{\mu\nu} = p'[(1 + w'^{-}1)\,u_\mu u_\nu - g_{\mu\nu}] \tag{138}$$

which is named the gravitational aether. For a slow varying equation of state $w = p/\rho \equiv \dot{p}/\dot{\rho}$, the effect of gravitational aether is simply to renormalize the effective gravitational constant:

$$G_{eff} = [1 + w + \mathcal{O}(w^2u^2)]\,G_N \tag{139}$$

where $G_N = 3G'/4$ and the size of corrections is determined by the velocity offset between aether and matter. The theory also incorporates slow-roll inflation and in another situation the gravitational aether is interpreted as a thermodynamic description of gravity, the technicalities of which include the proposal of a finite temperature correction to the equation of state of gravity, which has potential to explain the current accelerating expansion of the universe as a consequence of the formation of stellar mass black holes.

6 Advent of Einstein-Aether Theories

A scholarly definition of Einstein-Aether theory is, a generally co-variant theory of gravity coupled to a dynamical, unit time-like vector field that breaks local Lorentz symmetry [Jacobson1]. The action of the theory is given by,

$$S = \frac{1}{16\pi G_N}\int d^4x\sqrt{-g}\mathcal{L} \tag{140}$$

where G_N is the Newton's constant and g is a metric with the signature (+---). The Lagrangian density is,

$$\mathcal{L} = -R - K^{ab}_{mn}\nabla_a u^m \nabla_b u^n - \lambda(g_a b u^a u^b - 1) \tag{141}$$

R is the Ricci scalar, ∇ is the covariant derivative and K (a tensor) is expressed as,

$$K^{ab}_{mn} = c_1 g^{ab} g_{mn} + c_2 \delta^a_m \delta^b_n + c_4 u^a u^b g_{mn} \tag{142}$$

Now one might ponder about the relevance of this topic to our paper. In a sense, does the "aether" in Einstein-Aether theory really correspond to the one regarded as a mechanical medium required for the propagation of electromagnetic fields? The answer is perhaps no, but what it does correspond to without any doubt is the existence of a preferred frame, which is one of the central arguments of our entire formalism. In [Jacobson1], Ted Jacobson et al. write with regards to the preferred reference frame,

> "Such a frame would not be determined by a circumstance such as the moon's gravitational tidal field, or the thermal cosmic microwave background radiation, but rather would be inherent and unavoidable. Considerations of quantum gravity have in multiple ways led to this question, and it has also been asked in the context of cosmology, where various puzzles hint that perhaps something basic is missing in the standard relativistic framework."

Einstein's general theory of relativity has been founded on the principle of local Lorentz invariance. However the theory under consideration in this section violates Lorentz symmetry, which clearly puts us in a state of contradiction with respect to the true nature of gravity. It is not easy for physicists to totally abandon a central concept (here, general covariance). Thus to be on the safer side, Einstein-Aether theory's motivation is to test whether a general covariant model coupled to a preferred frame of reference makes reasonable predictions. General covariance as a principle architect of Einstein's description of gravity combined with the special frame (aether) yields a possible new approach towards understanding nature, thus the name Einstein-Aether theory.

The violation of local Lorentz invariance due to preferred frame effects also has a viable route to quantum gravity as cited in [Jacobson1]. Quoting [Jacobson1],

> "Lorentz symmetry violation by preferred frame effects has been much studied in non-gravitational physics, and is currently receiving attention as a possible window on quantum gravity".

Thus the Einstein-Aether theory is in correlation with most of the arguments advocated in this work, if not all. The exploration of this theory has led to many successful developments such as, new method of describing black hole mechanics [cite Brendan Z Foster], black hole solutions [cite Eling-Jacobson], spherical solutions [cite Eling-Jacobson2], gravitational spectrum of black holes [cite Konoplya-Zhidenko], solution of neutron stars [cite Eling-Jacobson-Miller], white hole solution [cite Akhoury-Garfinkle-Gupta], certain extensions of Einstein-Aether theories [many citations] to name but a few.

At this stage we are interested in a yet another significant work of Ted Jacobson et. al., in which they study a linearized theory of an aether coupled to gravity and compute the speed and polarization of all the wave modes [cite Einstein-Aether waves]. Among other things, it may prove to be useful for finding out the observational signatures of an aether field. Some important highlights of this work are given here: The first step in finding the wave modes is to linearize the field equations about the flat background solution with Minkowski metric η_{ab} and constant unit vector u^a. The expressions of the expanded fields are,

$$g_{ab} = \eta_{ab} + \gamma_{ab} \tag{143}$$

$$u^a = u^a + v^a \tag{144}$$

The aether perturbations are coupled to the metric perturbations due to the presence of the background aether vector u^a. Now in the general theory of relativity, there are two modes per spatial wave vector and v^a corresponds to three independent degrees of freedom therefore in the Einstein-Aether theory there would be a total of 5 modes. The two modes correspond to the usual gravitational waves and which are found when all the polarization components vanish except ϵ_1, ϵ_2, ϵ_3. One can infer from this that the aether field is a larger framework and gravitational waves are only a part of that larger manifold. Now a rather dramatic case also occurs in which the aether wave speeds are generally infinite. This happens because no time derivatives of the aether field then arise in the field equations. The expression for energy in the linearized theory hasn't been worked out in their paper and is left as an open problem.

References

[1] J. Rembielinski, K. A. Smolinski, *Quantum Preferred Frame: Does It Really Exist?*, EPL, **88** 10005 (2009). arXiv:0910.5324 [quant-ph]

[2] L. Hardy, *Quantum mechanics, local realistic theories, and Lorentz-invariant realistic theories*, Phys. Rev. Lett. **68**, 2981 (1992).

[3] Georgy I. Burde, *Special relativity with a preferred frame and the relativity principle: cosmological implications* , arXiv:1610.08771 [physics.gen-ph] (2016).

[4] T. Jacobson, D. Mattingly, *Gravity with a dynamical preferred frame*, Phys. Rev. D64 024028 (2001). arXiv:gr-qc/0007031

[5] T. Jacobson, D. Mattingly, *Relativistic gravity with a dynamical preferred frame*, arXiv:gr-qc/0112012 (2001).

[6] N. Afshordi, *Reviving Gravity's Aether in Einstein's Universe*, arXiv:1004.2901 (2010).

[7] N. Afshordi, *Where will Einstein fail? Lessons for gravity and cosmology*, Bull. Astr. Soc. India **40**, 1–20 (2012). arXiv:1203.3827 [astro-ph.CO]

[8] I. Carruthers, T. Jacobson, *Cosmic alignment of the aether*, Phys. Rev. D83:024034 (2011). arXiv:1011.6466 [gr-qc]

[9] Lachezar S. Simeonov, *Mechanical model of the inhomogeneous Maxwell's equations and of Lorentz transformations*, arXiv e-print:2007.02004 (2020).

[10] Planck Collaboration VII: Y. Akrami, et al., arXiv:1906.02552 (2019).

[11] L. Landau, E. Lifshitz, *A Course of Theoretical Physics*, Pergamon Press (1940).

[12] A. Einstein, *Zur Elektrodynamik bewegter Körper*, Annalen der physik **322(10)** 891-921 (1905).

[13] W. L. Craig, *Time and the Metaphysics of Relativity*, Springer (2001). https://doi.org/10.1007/978-94-017-3532-2

[14] W. L. Craig, *God and Real Time*, Religious Studies **26(3)** pp: 335-347 (1990).

[15] A. Suarez, *Entanglement and time*, arXiv:quant-ph/0311004 (2003).

[16] James C. Maxwell, *A Dynamical Theory of the Electromagnetic Field* Phil.Trans. Royal Soc London **155** 459–512 (1865).

[17] A. A. Logunov. *Henri Poincaré and relativity theory* Moscow: Nauka, 252 p (2005).

[18] Poincare H. *The present and future of mathematical physics.* Talk to Congress of arts and science at Saint-Louis (September 1904) // Bulletin des Sciences Mathematiques. – December 1904– Vol. 28, Ser. 2. P. 302. See also: The Monist.– January 1905. – Vol. XV, No. 1. See also: The relativity principle. M.: Atomizdat, 1973. p. 27. (in Russian)

[19] Poincare H. *Sur la dynamique de l'electron* Comptes Rendues. Vol. 140. P. 1504. (1905) See also: The relativity principle. M.: Atomizdat, 1973. p. 90. (in Russian) See also: Logunov A.A. On the articles by Henri Poincare ON THE DYNAMICS OF THE ELECTRON. Publishing Department of the Joint Institute for Nuclear Research. Dubna. 1995.

[20] Poincare H. *Sur la dynamique de l'electron* Rendiconti del Circolo Matematico di Palermo. 1906. Vol. XXI. P. 129. See also: The relativity principle. M.: Atomizdat, 1973. p. 118. (in Russian) See also: Logunov A.A. On the articles by Henri Poincare ON THE DYNAMICS OF THE ELECTRON. Publishing Department of the Joint Institute for Nuclear Research. Dubna. 1995.

[21] Hermann Weyl, *Raum. Zeit. Materie (Space. Time. Matter.)* Springer-Verlag (1923). https://doi.org/10.1007/978-3-642-98950-6

[22] Max Jammer, *Concepts of Mass in Classical and Modern Physics* Russian translation: Moscow, "Progress", p. 182 (1967).

[23] Poincare H. *The Relativity of Space*, in Science and Method (1897).

[24] R. Penrose, *The Road to Reality*, Jonathan Cape , 1094 pp. (2004).

[25] R. Descartes, *Discourse on the Method of Rightly Conducting One's Reason and of Seeking Truth in the Sciences* (French: Discours de la Méthode Pour bien conduire sa raison, et chercher la vérité dans les sciences) (1637).

[26] A. Knight, *Macroscopic Quantum Superpositions Cannot Be Measured, Even in Principle*, philarchive (2020).

[27] K. Godel. *Uber formal unentscheidbare S¨atze der Principia Mathematica und verwandter Systeme, I,* Monatshefte f¨ur Mathematik und Physik. **38(1)**, pp 173-198 (1931).

[28] E.C.G. Sudarshan, *The Theory of Particles Traveling Faster Than Light I*, Symposia on Theoretical Physics and Mathematics Vol. 10 (Plenum Press, New York, 1970).

[29] G. Feinberg, *Possibility of Faster-Than-Light Particles* Physical Review **159 (5)**: 1089–1105 (1967).

[30] Adam G. Riess et. al., *Observational evidence from supernovae for an accelerating universe and a cosmological constant* Astronomical Journal **116 (3)**: 1009–1038 (1998). arXiv:astro-ph/9805201

[31] S. Perlmutter et. al., *Measurements of Omega and Lambda from 42 high redshift supernovae* Astrophysical Journal **517 (2)**: 565–586 (1999). arXiv:astro-ph/9812133

[32] Albert A. Michelson, Edward W. Morley, *On the Relative Motion of the Earth and the Luminiferous Ether*, American Journal of Science **34 (203)**: 333–345 (1887).

[33] P. Dirac, *Is there an Aether?*, Nature **168** p. 906 (1951).

[34] https://www.researchgate.net/post/Michelson-Morley_experiment_can_it_really_disprove_ether

[35] Reginald T. Cahill, Kirsty Kitto, *Michelson-Morley Experiments Revisited and the Cosmic Background Radiation Preferred Frame*, arXiv:physics/0205065 (2002).

[36] H.A. Munera, *Michelson-Morley Experiments Revisited: Systematic Errors, Consistency Among Different Experiments, and Compatibility with Absolute Space*, Aperion **5(1-2)** 37-54 (1998).

[37] I. Perez, *The Physics Surrounding the Michelson-Morley Experiment and a New Æther Theory*, arXiv:1004.0716 [physics.gen-ph] (2010).

[38] M. Fedi, *A Superfluid Theory of Everything?*, HAL Id: hal-01312579 (2016).

[39] Klaus Wilhelm, Bhola N. Dwivedi, *Michelson-Morley experiment, Doppler effect, aberration of light and the aether concept*, arXiv:1603.05904 [physics.gen-ph] (2016).

[40] Reginald T. Cahill, *The Michelson and Morley 1887 Experiment and the Discovery of Absolute Motion*, Progr. Phys. **3** 25-29 (2005). arXiv:physics/0508174

[41] https://github.com/xjtian/class_notes/blob/master/PHYS273/interference.tex

[42] B. P. Abbott et al. (LIGO Scientific Collaboration and Virgo Collaboration), *Observation of Gravitational Waves from a Binary Black Hole Merger*, Phys. Rev. Lett. **116** 061102 (2016).

[43] R. Aschheim, L. Bubuianu, Fang Fang, Klee Irwin, V. Ruchin, S. Vacaru, *Starobinsky Inflation and Dark Energy and Dark Matter Effects from Quasicrystal Like Spacetime Structures*, Annals of Physics **394** 120-138 (2018). arXiv:1611.04858

[44] Barton Zwiebach, *A first course in string theory*, Cambridge University Press (2004).

[45] Elias Kiritsis, *String theory in a nutshell*, Princeton University Press (2019).

[46] Alan Guth lecture notes, Relativistic Quantum Field Theory I, Massachusetts Institute of Technology (2008).

[47] J. Maldacena, *The large-N limit of superconformal field theories and supergravity*, International journal of theoretical physics **38 (4)** 1113-1133 (1999). arXiv:hep-th/9711200

[48] Veronika E Hubeny, Shiraz Minwalla, Mukund Rangamani, *The fluid/gravity correspondence*, arXiv:1107.5780 [hep-th] (2011).

[49] Veronika E Hubeny, *The fluid/gravity correspondence: a new perspective on the membrane paradigm*, Classical and Quantum Gravity **28 (11)** 114007 (2011). HAL Id: hal-00705158

[50] Franck Delplace, *Liquid Spacetime (Aether) Viscosity, A Way To Unify Physics*, GS Journal (2014).

[51] Maurice J. Dupre, Frank J. Tipler, *General Relativity As an Aether Theory*, International Journal of Modern Physics D21 No. 02 1250011 (2012). arXiv:1007.4572 [gr-qc]

[52] N. Afshordi, *Gravitational Aether and the thermodynamic solution to the cosmological constant problem*, arXiv:0807.2639 [astro-ph] (2008).

[53] C. Eling, T. Jacobson, D. Mattingly, *Einstein-Aether Theory*, Deserfest proceedings (World Scientific). arXiv:gr-qc/0410001 [gr-qc] (2004)

[54] Brendan Z. Foster, *Noether charges and black hole mechanics in Einstein-aether theory*, Phys. Rev. D73 024005 (2006). arXiv:gr-qc/0509121

[55] C. Eling, T. Jacobson, *Black Holes in Einstein-Aether Theory*, Class. Quant. Grav. **23**:5643-5660 (2006). arXiv:gr-qc/0604088

[56] C. Eling, T. Jacobson, *Spherical Solutions in Einstein-Aether Theory: Static Aether and Stars*, Class. Quant. Grav. **23**:5625-5642 (2006). arXiv:gr-qc/0603058

[57] R. A. Konoplya, A. Zhidenko, *Gravitational spectrum of black holes in the Einstein-Aether theory*, Phys. Lett. B648:236-239 (2007). arXiv:hep-th/0611226

[58] C. Eling, T. Jacobson, M. C. Miller, *Neutron stars in Einstein-aether theory*, Phys. Rev. D76:042003 (2007). arXiv:0705.1565 [gr-qc]

[59] R. Akhoury, D. Garfinkle, N. Gupta, *White holes in Einstein-aether theory*, arXiv:1608.06970 [gr-qc] (2016).

[60] Alexander B. Balakin, *Axionic extension of the Einstein-aether theory*, Phys. Rev. D94 024021 (2016). arXiv:1606.09286 [gr-qc]

[61] T. Jacobson, D. Mattingly, *Einstein-Aether Waves*, Phys. Rev. D70:024003 (2004). arXiv:gr-qc/0402005