**Michelson and Morley, Sagnac, the train and the ongoing ether debate**


## Abstract

The 1887 Michelson and Morley experiment continues to be widely seen by mainstream physicists as producing a null result. This is not correct. It produced a less than expected result that at that time could not be explained by science. It seems likely that mainstream physicists will continue to see the results of the Michelson and Morley experiment as being a null result. The reasons for this seem unfathomable. Numerous experiments conducted be respected physicists since 1887 have demonstrated a positive result by replicable experiments. This includes Sagnac in 1913. The Sagnac experiment has never been seriously challenged by the physics community. As a concept scientist I talk about these matters. I have employed Einstein's lightning, train and observers analogy as a means of demonstrating that the Sagnac effect seems to be a demonstrably reliable theory. This includes other similar theories as well. This is in regards to the splitting of light and the subsequent projection of the resulting two new light sources onto the same surface.



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## Introduction

I introduce you to the Sagnac effect in physics [1]. The 1930's Sagnac experiment, together with a long succession of confirming experiments, demonstrates the validity of Newtonian type ether theory. The successful Sagnac experiment seems to be rarely discussed in mainstream relativity physics literature. Neither is a succession of similar experiments that offer evidence that ether theory is a valid inertial reference frame with respect to helping to understand and describe universal reality physics.

As a concept scientist, today I offer a theory that may help you to better understand what appears to be the value of the ether inertial frame point of universal reference. It is likely that I am introducing you to new ideas. I do not seek to prove anything with this blog. I am not capable of doing so anyway. I offer my readers a minimal number of references. For this reason you should consider this blog as being a succession of ideas for you to consider.

If you have a deep interest in physics, it is likely you would be aware of the alleged null result of the 1887 Michelson and Morley experiment [2] that sought to establish if Newtonian type ether theory was a valid hypothesis or not. If you look carefully through the literature you will find the Michelson and Morley experiment was never a null result. Professional physicists at the time described it as being an incomplete result. In the 1920's, Dayton Miller's ether experiment [3] plus others around that time [including Ives and Stilwell] [4] demonstrated that the original 1887 Michelson and Morley experiment had greater merit than first thought.

In 1913 the French scientist Georges Sagnac [5] demonstrated the veracity of ether theory in the wider physical debate. Einstein knew about the successful Sagnac experiment as well. There are odd times around that same period in which Einstein admitted the necessity to have a physical inertia frame in order to make both of his models "work". You will find a reference to Einstein's apparent change of heart regarding ether in reference [18]. I have emboldened text that I feel may most interest you. It is important that you know that there are various ether theories. The common factor in all of these theories is that ether space is without time. Ether space is absolute space. Einstein's special and general relativity theories can be seen as concurrent theories with respect to the absolute ether inertia frame of reference. By this I mean the universal frame of reference. You will also see where I discuss simultaneity is possible in ether theory. If you are keenly interested in this history and evolution of the ether debate in the pre-1950 period, I strongly urge you to read a paper written by

Lloyd S. Swenson entitled “The Michelson-Morley-Miller experiments before and after 1905” [6].

**The main text**

The Sagnac effect is important because it addresses the issue of the isotrophy of light velocity [with respect to the observer] in all the possible inertial frames. If the isotropic speed of light is not found to be constant, then this provides problems for both of Einstein’s relativity theories. This is because he would have needed to modify his special relativity and general relativity models in order to make them compatible with a motionless ether. He did not do this because he felt that his theories made ether unnecessary. The physicists Lorentz [7] and Poincare [8] showed that such a change would have been relatively straightforward.

The Sagnac effect resolves any such dilemma by not postulating the speed of light, by assuming the existence of a preferred inertial frame [ether] in which simultaneity holds. Ether is called preferred because it is where the first synchronisation of clocks is made, and where a frame of reference is moving at the speed of light. This video* [9] illustratively demonstrates the Sagnac experiment quite well. A kit for home use [10] to study the Sagnac effect is available as well. For professional scientists I offer this additional link for you to consider [11].

*I apologise to my readers that at the end of this video it contains material of a religious nature. However, I have incorporated the video because I feel that it demonstrates the Sagnac effect quite well.

I suggest that the speed of light is meaningless if space does not contain existing co-ordinates that are mobile or fixed, i.e., without time. The laws of nature tell us that such hidden co-ordinates exist and therefore geometry and

algebra may be able to predict both what these hidden co-ordinates mean, and then predict their relationship to the holistic universe. The existence of a preferred inertial reference frame would seem to be a sound way of helping to understand such hidden co-ordinates. The eminent 19th century physicist Poincare agreed that such co-ordinates must exist. They already exist as a mathematical concept.

Einstein's theories demonstrate that a preferred initial frame is unnecessary. However, they rely on the eyes of observers, but these observers are subjective. The Sagnac experiment, which has been replicated, also tells us that an objective co-ordinate must exist in real space because they can be explained by such experiments. These are experiments that tell scientists that there is such a thing as absolute space, and thus ether theory is a valid theory. Relativity theory seems to make no attempt to provide physical meaning to its mathematical construction [because it does not need to], whereas an ether inertial frame does. Einstein argued that they need not do so.

The Sagnac effect physically demonstrates this point quite clearly. As I indicated in my introduction, there are other theories that have been tested that provide additional validity to the Sagnac theory. These include the Michelson, Gale and Pearson experiment [12] in 1925, and perhaps, more importantly, the Ives and Stilwell Brussels canal experiment in 1925. The long term Dayton Miller experiment [13] has also provided much highly useful data that complements all of these tests and experiments. Miller's testing ranged from the late 1920s well into the 1930s. I would like to introduce you to the Kennedy and Thorndike experiment [14] at this time as well. From my secondary reading it seems that not many physicists have heard about this experiment before.

Einstein's relativity theories appear to loosely deny the existence of such a universal ether and its alleged hidden co-ordinates. However, at different times

Einstein did clearly state that an ether inertial frame of reference exists but he never widely expressed this point of view to the media of his time. [He mostly seems to have stated this idea at private lectures]. An example of this is a lecture that Einstein delivered in 1924 which I have discussed above and you can find in reference [18]. I have emboldened the sections that I feel are more relevant to my readers.

**Let me summarise as follows:**

1] There is an absolute space inertial frame of reference.

2] There are hidden co-ordinates within the inertial ether frame.

3] The effects of these hidden co-ordinates, together with what meaning they may have, are testable and demonstrable by experiments such as the 1913 Sagnac experiment and others like it as I have discussed.

4] Einstein seems to have been ambivalent as to whether there existed an ether inertial frame of reference, because he thought it was not necessarily relevant to his relativity models. At the same time however, Einstein seems to have said it was likely that ether theory might be desirable for inclusion within both of his relativity models.

Many contemporary physicists continue to believe that ether theory is unnecessary in their attempts to create a theory of everything. I will shortly describe how that, in my opinion, absolute ether theory might help to explain the lightning strike, the moving train and observer analogy that Einstein asked his peers to consider. Before doing this, I will add additional information that I believe will help you fully understand what I am talking about in my limited description of differing events relating to Einstein's moving train analogy.

1] Light should be seen as being a disturbance in the ether medium travelling at constant speed with respect to the medium of the inertial reference frame, [as when light changes speed because of what it may be travelling through, such as air, a vacuum or a transparent object like a diamond.] This is not the same as what an observer sees in a chosen frame as in the case of special relativity theory.

2] The velocity of light in the ether medium is the distance travelled divided by the time it takes to travel the distance. The distance measured in the ether medium is by both material rods [15] and mechanical clocks [16] by means of time dilation. Material rods shrink with motion through dilation [through relativistic effects] relating to any given speed and clocks slow down too. This is via dilation with respect to measurement.

3] As clocks slow with movement in the ether inertia frame, the time varies between clocks at rest in the ether frame. All reference frames chosen by observers in Einstein's relativity modelling should be considered as being within the universal ether frame. In other words, where Special Relativity theory says that the two return journey events on all platforms are the same, it is not correct.

4] Light travelling between two points should be perceived as and treated as a single event. In a light and mirror experiment, the return trip of light to a common point is an event. The point where the light separates for the return journey is an event unto itself. Such a 'space' exists between all events such as in the mirror experiment. and this space should be seen as being without absolute time. This is because all events occur within hidden co-ordinates of a single inertia ether, not just a single reference frame chosen by an observer, as is the case in special relativity theory. This is why from a special relativity

frame of reference the two journeys are unequal. The return trip from point B to point A is slower.

5] The measurement of a light signal between two points (say mirrors) necessitates there being two clocks A and B. Clock A is the clock at the point of sending and clock B is the point of receiving. Both clocks must be set at the same run rate. The contraction of clock B when it is moved from point A to point B also needs adjusting. This is because the movement between both reference points A and B is a separate reference frame unto itself with respect to the earth. When clocks dilate they contract with respect to the universal inertia ether, not clock time as is commonly believed by relativity theory scientists.

6] The isotropic radiation effect [17] of moving light also manipulates matter on an atomic scale. This would also occur in relation to the wider universal inertial frame.

**The Einstein dual lightning strike analogy**

Within Einstein's analogy there are several different events. These include two prospective lightning strikes upon the train and a separate event relating to the formation of plasma caused by the two lightning strikes. In turn, these two strikes are also relevant to the moving train with respect to the rails upon which the train is moving. This includes the observer sitting on the embankment who in turn is located in respect to the centre of the moving train as Einstein's analogy dictates. This is in addition to the wider events in the chosen frame of reference. Remember that these events are also taking place with respect to the wider universal inertia reference frame of ether and that there is a relativity clock time delay between each event that needs to be considered between these

events. This includes the mechanics of clocks. Also all moving objects, including the train itself, shrink as a result of such movement.

Place one clock at the front of the train and walk down to the other end of the train and place another clock at the rear. The clock at the front of the train records the lightning strike as being in local [relative] time, but the clock at the rear of the train, through time dilation due to the act of walking to place the second clock at the rear of the train indicates a slower time. Furthermore clocks fastened externally to the train at each end would record the same degree of dilation if an observer were to walk the length of the roof of the train.

Let us say that the train is moving forward at one hundred kilometres per hour and the length of the train is eighty metres. This means that the events are occurring within one reference frame as chosen by an observer who is observing all events adjacent and related to the embankment as well as adjacent to the moving train. The girl on the train would be observing the events of dual lightning strikes only with respect to the event within the train itself. This is by means of the respective isotropic effects of both lightning strikes that would have been [relatively] instantaneous as per Einstein's analogy. Both isotropic effects of ether lightning strikes would reach the girl in the centre of the train at C [i.e. the speed of light] The girl's observation of the observer on the embankment would have also been relating to the same two instantaneous isotropic lights as well. Keep in mind that the same events are occurring with respect to the moving train as well as the wider ether inertial frame.

From these combined events it can be seen that it would be impossible to observe that the two lightning strikes were simultaneous. The clock time dilation effects between both events would prohibit this. The same applies to the girl on the train for similar relative clock time reasons. It is not only the clock time dilation effect that would prohibit this, but also the contraction in length of the train itself, as it was moving instead of being at rest relative to an

observer. However, because simultaneity is allowed in the in the ether inertia frame. I will discuss why I feel that this is the case.

Because there is a delay between all events, no matter how large or how small these events may be. This delay is represented by the absoluteness of the universal ether. This delay [I will call NOW] is not measurable by clocks. It simply “IS”. It is representative of the wider influence, and effect of nature. This is nature that has its own already existing hidden co-ordinates in which Einstein’s lightning strike analogy applies.

An observer positioned upon the motionless Earth gravity field would observe the commonality effect of the special relativity reference frame chosen by the observer on the embankment. The observer on the embankment cannot do this. This is because he is included within his own choice of reference frames which in turn is relative from the wider inertia ether frame. This is the reference frame that then must hold. It must be treated as the dominant frame. This is in respect to the observer in the motionless Earth gravity field that in turn is relative to the universal inertial frame of ether. These words draw attention to the commonality to all that “IS” with respect to the universal inertial frame of ether.

I argue that at the relative time that the two lightening strikes hit the train, and from the universal ether inertia frame point of reference (absolute time), as well as the special relativity perspective, there would have been a analogous NOW. From a special relativity perspective this is unknowable because it is unmeasurable and not observable. However, from an observer in the first gravity field it would be. What must be considered is that both lightening strikes hitting the train were two separate events.

I further suggest that this NOW that I have introduced you to has no past and no future. This means that until the indeterminable NOW ‘period’ moves into

the past the special relativity reference is “frozen” in relativity clock time. This is before rods commence shrinking and clocks as discussed above run slower in absolute ether time. An observer within the absolute ether of motionless Earth gravitation would observe the NOW. This is a NOW that he would have also observe the position of a train not only relevant to an observer of the two ether inertial frame lightning strikes at each end of the train but also the girl in the middle of the train. [Light and its isotropic effects are related to ether as demonstrated by the Sagnac experiment]. By this I mean that the observer in the motionless gravitational frame of ether reference would then mathematically know exactly where the centre of the train was during without time of the absolute state of NOW as I have been discussing.

If the train is eighty metres in length, then the centre of the train would notionally be at rest with each half of the train resting equally at the point of the absolute NOW. This NOW relative to the train is also relative to the parallel railway lines upon which the train is travelling. The implications of this are that once the relative point with respect to the railway track of NOW has passed [the train continues to move forward in relation to this point]. From this it is then possible to employ this railway line reference point to mathematically determine who saw the lightning strikes happen at the same time, and who did not, i.e., the observer and the girl. Furthermore, who saw the lightning strikes separate with respect to each other. This includes the known length of the train, the known speed of the train and the point of reference on the railway tracks with respect to the embankment. This is from the point of view of the observer on the embankment. The observer however would not know that he was frozen into the “NOW” as is observed by the another observer in the motionless gravitation of ether in the inertial ether frame. The slowing clocks on the train, as well as the contraction of the moving train with respect to the ether frame observer, the time dilation of clock time and shrinkage of the train itself play no role in this ether frame model of event related conditions. It only would

when Einstein's special relativity theory analogy applied to the observer on the embankment in his chosen reference frame.

I believe that my review of the Sagnac experiment demonstrates that there are two different light sources that emanated from a single light source that then come back together to form a single effect of light. The splitting of light this way demonstrates the difficulty that emanated from the Michelson and Morley experiment that allegedly had a null result. This is incorrect as was demonstrated by Dayton Miller and numerous other highly respected physicists around the same time.



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When we speak here of aether, we are, of course, not referring to the corporeal aether of mechanical wave-theory that underlies Newtonian mechanics, whose individual points each have a velocity assigned to them. This theoretical construct has, in my opinion, been superseded by the special theory of relativity. **Rather the discussion concerns, much more generally, those things thought of as physically real which, besides ponderable matter consisting of electrical elementary particles, play a role in the causal nexus of physics. Instead of**

**‘aether’, one could equally well speak of ‘the physical qualities of space’**. Now, it might be claimed that this concept covers all objects of physics, for according to consistent field theory, even ponderable matter, or its constituent elementary particles, are to be understood as fields of some kind or particular ‘states of space’. But it must be admitted that such a view would be premature, since, thus far, all efforts directed toward this goal have foundered. So we are effectively forced by the current state of things to distinguish between matter and aether, even though we may hope that future generations will transcend this dualistic conception and replace it with a unified theory, as the field theoreticians of our day have tried in vain to accomplish.

It is usually believed that aether is foreign to Newtonian physics and that it was only the wave theory of light which introduced the notion of an omnipresent medium influencing, and affected by, physical phenomena. But this is not the case. Newtonian mechanics had its ‘aether’ in the sense indicated, albeit under the name ‘absolute space’. To get a clear understanding of this and, at the same time, to explore more fully the concept of aether, we must take a step back.

We will consider first a branch of physics which makes do without any notion of aether, namely the geometry of Euclid, understood as the study of the possible ways of bringing essentially rigid bodies into contact with each other. (For now, we will set to one side light rays, which may also contribute to the development of geometrical concepts and theorems.) The laws concerning the placement of rigid bodies, excluding relative motion, temperature and the influence of deformations, as laid down in an idealised way in Euclid’s geometry, derive from the concept of a rigid body. Any environmental influence which could be thought of as existing

independently of those bodies and as acting on them and influencing the laws governing their placement is unknown to Euclidean geometry. The same holds for the non-Euclidean geometries of constant curvature if these are understood as conceivable laws of nature. It would be different if we were to find ourselves forced to adopt a geometry of variable curvature. This would mean that the laws governing the ways essentially rigid bodies can be brought into contact would be different in different cases, depending on environmental influences. **Here we would have to say that, in the sense we are considering, such a theory would require an aether hypothesis. Its aether would be something every bit as physically real as matter. If the laws of placement were impervious to the influence of physical factors, such as the accumulation and state of motion of bodies in the environment, but irrevocably given, then we would call this aether 'absolute', i.e. by its nature independent of any influence.**

The kinematics, or phoronomy, of classical physics had as little need of an aether as (physically interpreted) Euclidean geometry has. For its laws have a clear physical meaning only if we assume that the special-relativistic influences of motion on rulers and clocks do not exist. Not so in the dynamics of Galileo and Newton. The law of motion 'force equals mass times acceleration', does not consist only of a statement about material systems, not even if, according to Newton's fundamental law of astronomy, the force is expressed at a distance, i.e. by quantities whose 'real definition' [*definitio realis*, a definition in terms of the object's distinguishing properties] can be based on measurements involving rigid bodies. For the 'real definition' of acceleration cannot be completely reduced to observations of rigid bodies and clocks. It cannot be reduced to the measurable distances between the points that make up the

mechanical system. Its definition requires also a coordinate system or reference body having some suitable state of motion. If a different coordinate system is chosen, the Newtonian equations do not hold with respect to this new coordinate system. With those equations, the milieu in which the bodies move appears as an implicit, real factor in the laws of motion, alongside the real bodies themselves and the distances that massive bodies define. In contrast to geometry and kinematics, the 'space' of Newton's theory of motion possesses physical reality. **We will call this physical reality which enters the Newtonian law of motion alongside the observable, ponderable real bodies, the aether of mechanics. The occurrence of centrifugal effects with a (rotating) body, whose material points do not change their distances from one another, shows that this aether is not to be understood as a mere hallucination of the Newtonian theory, but rather that i*t corresponds to something real that exists in nature.***

We see that, for Newton, 'space' was something physically real, in spite of the curiously indirect way this real thing reaches our awareness. Ernst Mach, the first after Newton to subject the foundations of mechanics to a deep analysis, perceived this clearly. He sought to escape this hypothesis of the 'mechanical aether' by reducing inertia to immediate interaction between the perceived mass and all other masses of the universe. This view was certainly a logical possibility but, as a theory involving action at a distance, cannot be taken seriously today. The mechanical aether– which Newton called 'absolute space'–must remain for us a physical reality. Of course, one must not be tempted by the expression aether into thinking that, like the physicists of the 19th century, we have in mind something analogous to ponderable matter.

When Newton referred to the space of physics as ‘absolute’, he was thinking of yet another property of what we call here aether. Every physical thing influences others and is, it its turn, generally influenced by other things. This does not however apply to the aether of Newtonian mechanics. For the inertia-giving property of this aether is, according to classical mechanics, not susceptible to any influence, neither from the configuration of matter nor anything else. Hence the term ‘absolute’.

Only in recent years has it become clear to physicists that the preferred nature of initial systems, as opposed to non-inertial systems, requires a real cause. Viewed historically, the aether hypothesis has emerged in its present form by a process of sublimation from the mechanical aether hypothesis of optics. After long and fruitless efforts, physicists became convinced that light was not to be understood as the motion of an inertial, elastic medium, that the electromagnetic fields of Maxwell’s theory could not be construed as mechanical. So under the pressure of this failure, the electromagnetic fields had gradually come to be regarded as the final, irreducible physical reality, as states of the aether, impervious to further explanation. What remained of the mechanical theory was its definite state of motion; it somehow embodied a state of absolute rest. While at least in Newtonian mechanics all inertial systems were equivalent, it seemed that, in the Maxwell-Lorentz theory, the state of motion of the preferred coordinate system (at rest with respect to the aether) was completely determined. It was accepted implicitly that this preferred coordinate system was also an inertial system, i.e. that the principle of inertia [Newton’s first law] applied relative to the electromagnetic aether.

There was another way too in which the Maxwell-Lorentz theory set back physicists’ basic understanding. Since electromagnetic fields were seen as

fundamental, irreducible entities, they seemed destined to rob ponderable masses, possessing inertia, of their primary meaning. It was shown by Maxwell's equations that a moving, electrically charged body is surrounded by a magnetic field whose energy is, to first approximation, a quadratic function of speed. It seemed only natural to conceive of all kinetic energy as electromagnetic energy. Thus one could hope to reduce mechanics to electromagnetism, since efforts to reduce electromagnetic phenomena to mechanics had failed. Indeed this looked all the more promising as it became apparent that all ponderable matter was composed of electromagnetic elementary particles. But there were two difficulties that could not be overcome. Firstly the Maxwell-Loretz equations could not explain how the electric charge constituting an electrical elementary particle can exist in equilibrium in spite of the forces of electrostatic repulsion. Secondly electromagnetic theory could not give a reasonably natural and satisfactory explanation of gravitation. Nevertheless the results that electromagnetic theory achieved for physics were so significant they came to be regarded as a completely secured possession, indeed as its most firmly established success.

The Maxwell-Lorentz theory eventually influenced our view of the theoretical basis to the extent that it led to the creation of the special theory of relativity. It was recognised that the equations of electromagnetism did not, in fact, single out one particular state of motion, but rather that, in accordance with these equations, just as with those of classical mechanics, there exists an infinite multitude of coordinate systems in mutually equivalent states of motion, providing the appropriate transformation formulas are used for the spatial and temporal coordinates. It is well known that this realisation entailed a profound modification, not only in our ideas about space and time, but also to

kinematics and dynamics. No longer was a special state of motion to be ascribed to the electromagnetic aether. Now, like the aether of classical mechanics, it resulted not in the favoring of a particular state of motion, only the favoring of a particular state of acceleration. Because it was no longer possible to speak, in any absolute sense, of simultaneous states at different locations in the aether, the aether became, as it were, four dimensional, since there was no objective way of ordering its states by time alone. According to special relativity too, the aether was absolute, since its influence on inertia and the propogation of light was thought of as being itself independent of physical influence. While classical physics took it for granted that the geometry of bodies was independent of their state of motion, the special theory of relativity stated that the laws of Euclidean geometry only apply to the positioning of bodies at rest with respect to one another when these bodies are at rest with respect to an inertial coordinate system.[1] This can be easily concluded from the so-called Lorentz contraction. Thus geometry, like dynamics, came to depend on the aether.

The general theory of relativity rectified a mischief of classical dynamics. According to the latter, inertia and gravity appear as quite different, mutually independent phenomena, even though they both depend on the same quantity, mass. The theory of relativity resolved this problem by establishing the behaviour of the electrically neutral point-mass by the law of the geodetic line, according to which inertial and gravitational effects are no longer considered as separate. In doing so, it attached characteristics to the aether which vary from point to point, determining the metric and the dynamic behaviour of material points, and determined, in their turn, by physical factors, namely the distribution of mass/energy.

Thus the aether of general relativity differs from those of classical mechanics and special relativity in that it is not ‘absolute’ but determined, in its locally variable characteristics, by ponderable matter. This determination is a complete one if the universe is finite and closed. That there are, in general relativity, no preferred spacetime coordinates uniquely associated with the metric is more characteristic of its mathematical form than its physical framework.

Even using mathematical apparatus of general relativity it has not been possible to reduce all of the inertia of mass to electromagnetic fields, or to fields in general. Neither are we yet, in my view, at the point of formally incorporating the electromagnetic forces into the scheme of general relativity. O**n the one hand, the metric tensor, which codetermines the phenomena of gravitation and inertia and, on the other, t*he tensor of the electromagnetic field appear still as different expressions of the state of the aether,* whose logical independence one is inclined to attribute rather to the *incompleteness of our theoretical ediface* than to a complex structure of reality.**

It is true that Weyl and Eddington have, by a generalisation of Riemannian geometry, found a mathematical system, in which both kinds of field appear to be unified under a single perspective. But the simplest field laws which that theory provides seem to me not to advance physical insight. On the whole, we seem to be much further now from an understanding of the fundamental laws of electromagnetism than we did at the beginning of this century. As justification for this opinion, I should here like to briefly refer to the problem of the magnetic fields of the earth and the sun, and also to the problem of light quanta, which problems have some bearing on the gross and fine structure of the electromagnetic field.

The earth and sun possess magnetic fields whose orientation and sense are closely related to the spin axes of these bodies. According to Maxwell's theory, these fields may be due to electric currents which flow in the opposite direction to the rotation of the earth and sun about their axes. Even sunspots, which there are good grounds to think of as vortices, posses analogous, and very powerful, magnetic fields. But it is hardly conceivable that, in all these cases, circuits or convection currents of sufficient strength are actually present. Rather it looks as if cyclic motion of neutral masses generated magnetic fields. Neither Maxwell's theory as originally conceived nor as extended in general relativity predict field generation of that sort. Here nature seems to point us toward some fundamental connection, not yet understood.[2]

If the case we have just discussed is one that field theory, in its current form, seems not yet able to address, the facts and ideas subsumed under quantum theory threaten to the blow the edifice of field theory to bits. Specifically, we find increasing arguments suggesting that the quanta of light are to be understood as physical reality, and that the electromagnetic field cannot be seen as the final reality to which all other physical objects can be reduced. As Planck's formula had already shown that the transmission of energy and momentum by radiation happens as if the latter consisted of particles moving at the speed of light, , with energy so Compton demonstrated, by his research into the scattering of X-rays by matter that scattering events occur in which quanta of light collide with electrons and transmit to them a portion of their energy, as a result of which the quanta of light undergo a change of energy and direction. It is at least a fact that X-rays experience such changes in frequency on

scattering (in agreement with the predictions of Debye and Compton) as quantum theory demands.

Recently there has appeared work by the Indian physicist Bose on the derivation of Planck's formula which is of particular significance to our theoretical understanding for the following reasons: hitherto all complete derivations of Planck's formula made some use of the hypothesis of the wave structure of radiation. So, for example, in the well-known Ehrenfest-Debye derivation, the factor  in this formula was deduced by counting the eigenvibrations of the cavity belonging to the frequency range . Bose replaces this derivation based on the ideas of wave theory with a gas-theoretical calculation which he applies to a quantum of light conceived of like some sort of molecule present in the cavity. This raises the question of whether it might perhaps also be possible to link the phenomena of diffraction and interference to quantum theory in such a way that the field-like concepts of the theory are presented only as expressions of the interaction between quanta, so that independent physical reality would no longer be ascribed to the fields.

The important fact that the radiation emitted is not, according to Bohr's frequency theory, determined by electrically charged masses which periodically cycle through occurrences of the same frequency can only strengthen this doubt of ours as to the independent reality of the wave field.

**But even if these possibilities do mature into an actual theory, we will not be able to do without the aether in theoretical physics**, that is, a continuum endowed with physical properties; for general relativity, to whose fundamental viewpoints physicists will always hold fast, rules out

direct action at a distance. ***But every theory of local action assumes continuous fields, and thus also the existence of an 'aether'.***
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