Poincare, Einstein and the Aether – 100 Years Later

Pharis E. Williams

2005

Relativity started with Galileo and his motion relative to the stars. Inertia came into the picture with Newton's laws of motion, as did the notion of motion in the absence of forces. James Clark Maxwell gave the scientific community a lot to think and write about when he fashioned and published his electromagnetic equations in 1873. A community that was, by this time, used to explaining physical phenomena in mechanistic descriptions found it difficult to come to grips with the field type equations Maxwell gave them. This desire for a mechanistic description for the propagation of light gave birth to the notion of a mechanical medium, the ether, in which light might propagate. Experiments were no help in continuing the mechanistic view of the world, as they could find no ether. Measurements of the speed of light with respect to the supposed ether came up with a negative result. Einstein looked at this result very differently than did his peers and took this to mean that the speed of light was a universal constant, no matter how one attempted to measure it. This different viewpoint gave rise, ultimately, to Einstein presenting two theories to the scientific community with the word 'relativity' in their titles.

Now one hundred years after Einstein presented the first of his theories of relativity this article is offered, not to pay tribute only to these contributions of Poincaré and Einstein, but to mark the centenary of the discoveries of 1905 by presenting a critical reconsideration of the ether idea in modern physics, astronomy and cosmology.

This is an interesting proposition in that it involves the reconsideration of a basic mechanistic description of such diverse fields as modern physics, astronomy and cosmology where the field description has won such a high level of acceptance. This particular article to this reconsideration will concentrate on the human tendency to fall into a habit and the contributions of Poincaré and Einstein.

H. Margenau, in *Integrative Principles of Modern Thought*, had these comments on Einstein's position on human traits, "Einstein recognized the fact that a person's view point was tainted by his experience. [Einstein's] unconventionality and his courage are attested not only by his scientific work, but also by his more incidental utterances. Common sense, he said, is merely the layer of prejudges which our early training in science has left in our minds. Following him, other scientists of this period took infallible and innate *lumen naturale* but merely the residue which advancing science has left in its wake and which has penetrated popular thinking. They heeded D'Alembert's admonition, 'Allez en avant, la foi vous viendra!'."

Poincaré may have shared this belief for he wrote, "If this intuition of distance, of direction, of the straight line, if, in a word, this direct intuition of space does not exist, whence comes it that we imagine we have it? If this is only an illusion, whence comes it that the illusion is so tenacious? This is what we must examine. There is no direct intuition of magnitude, as we have said, and we can only arrive at the relation of the magnitude to our measuring instruments. Accordingly we could not have constructed space if we had not had an instrument for measuring it. Well, that instrument to which we refer everything, which we use instinctively, is our own body. It is in reference to our own body that we locate exterior objects, and the only special relations of these objects that we can picture to ourselves are their relations with our body. It is our body that serves us, so to speak, as a system of axes of co-ordinates."

If one were to look at Poincaré's contributions to the philosophy of mathematics and science, one point to make is the way that Poincaré saw logic and intuition as playing a part in mathematical discovery. He wrote in *Mathematical definitions in education* (1904): “It is by logic we prove, it is by intuition that we invent.” A second point might well be his position on geometry, as was pointed out in one biography, in that “Poincaré believed that one could choose either Euclidean or non-Euclidean geometry as the geometry of physical space. He believed that because the two geometries were topologically equivalent then one could translate properties of one to the other, so neither is correct or false. For this reason he argued that Euclidean geometry would always be preferred by physicists. This, however, has not proved to be correct and experimental evidence now shows clearly that physical space is not Euclidean.”

As we now continue our critical reconsideration of the aether idea in modern physics, astronomy and cosmology, we do well to keep these human traits and ideas in mind. For example, the simple statement of conclusion of experimental evidence just mentioned may well be a result of the ‘tenacious common sense’ interpretation developed over the past century rather than an experimental inevitability. It has often been mentioned that Einstein’s contributions represented a very different point of view from that taken by most of his peers. What then might we gain if we do not follow the commonly accepted point of view in the critical reexamination?

The notion of an aether arose after Maxwell published his field equations wherein the speed of light did not depend upon a medium for its propagation. Einstein avoided the necessity of attempting to explain the method of propagation using mechanistic means by the simple assumption that the speed of light is an invariant regardless of the method of propagation or attempts to measure it. As experimental evidence has piled up during the intervening years, scientists have, in general, accepted this assumption. However, a couple of questions may be asked: “If this constancy of the speed of light is fundamental to both electromagnetism and gravity, does that not mean that there exists a fundamental connection between the two fields that remains to be learned?” and “How might one proceed to learn of such a fundamental connection?”

One recent contribution has began at the very different starting point of classical thermodynamics where the first law is a statement of conservation of energy that is a path dependent statement of energy transfer being the sum of independent forces acting on the system[1]. The key insight needed to understand the fundamental nature of the laws of thermodynamics is to note that the first law is a Pfaff differential equation and to apply the second law of thermodynamics as Caratheödory did in 1909. Caratheödory’s principle, which may be considered as the second law, guarantees the existence of a property called entropy along with the energy statement of the first law. The form of these laws are such that they may be expressed, without preference, in any coordinate system and of any dimension, as Einstein stated should be required of a fundamental set of laws. Though the necessary, complimentary existence of energy and entropy appears to complicate any mechanistic description of nature it is their simultaneous existence that provides a logical description.

From this starting point it was shown that, when only mechanical forces are allowed, there exists a fundamental, unique, absolute velocity. The velocity is fundamental in that it does not depend upon a specific type of force and, therefore, must affect the results of using all types of forces. It is unique in that there can only be one such velocity. It is absolute in the same sense that the zero of temperature is absolute: no force exists that can accelerate an object from below this velocity to a greater velocity. It is with interest that it may be noted that this absolute velocity arises from the consideration of constant velocity processes, which echoes Einstein’s inertial coordinate systems without the necessity of a force law. Independent of how the constancy of the speed of light may be supported; whether by simple assumption as Einstein did or by derivation from another acceptable law, as Williams did, the same relativistic transformations may be derived. However, an absolute velocity and the resulting transformations alone cannot tell the whole story. A velocity and transformations imply there are an underlying coordinate system and geometry.

The thermodynamic starting point to the derivation of the constancy of the speed of light may also be used to display the existence of mechanical entropy[2]. There are several definitions of entropy in use today. However, the one that best fits the concept of mechanical entropy is the one used in classical thermodynamics defining entropy as energy that becomes unavailable. The utility of introducing the concept of mechanical entropy here does not stem from a desire to add yet another concept of entropy to an already confusing array, but to point out its role in developing a different view of fields, forces, geometry and inertia.

The statement of the first law of thermodynamics may be made independent of the type of coordinate system one desires to use. This is to say that this fundamental law calls for no special coordinate system or geometry. The scientist is free to choose the Euclidean geometry as Poincaré noted. When one sees that the mechanical entropy must increase for isolated mechanical systems, one sees that the second law is requiring a variational principle. This variational principle of increasing mechanical entropy necessarily introduces both forces and geometry

Today the concept of entropy is almost universally related to order or information. However, the concept demanded by the second law is best thought of as 'energy that becomes unavailable' as the thermal engineers have been known to call it. In this form it is easier to connect the second law with the denial of perpetual motion as the more you do the greater the amount of energy that becomes unavailable. This becomes the entropy principle for isolated systems. For all other systems it requires the minimum free energy principle. This provides a variational principle that may be used to determine motion should a geometric metric also be given.

Bolstered by the fact that the laws support the special theory of relativity by providing Einstein's postulate concerning the constancy of the speed of light, there is more reason to believe that mechanics may indeed come from these laws. Again following the lead of thermodynamics where there is a choice of the variables one may choose with which to write the second order differential equations that give the stability conditions, so also is a choice provided for the description of mechanical systems stability. These differential equations are natural metrics for use in determining motion. Choosing the stability conditions in a manifold of space and entropy seems very unlike mechanics, yet when this metric is scaled using local time as the arc length a rewarding requirement occurs when an isolated system is considered. These fundamental laws do not provide a variational principle in time. Therefore, the scaled metric must be solved for the element of entropy before the principle of increasing entropy may be applied. This gives equations of motion in a Riemannian manifold as Einstein used in his relativistic theories.

The two most remarkable features of this result are; first the fundamental laws specify the geometry, and secondly, the laws require *two* metrics. The first metric is the relativistic metric whose arc length is the entropy playing the role of Einstein's proper time. Therefore, the mechanical entropy is proportional to Einstein's proper time and the principle of increasing entropy requires that proper time strictly obey the Arrow of Time for isolated systems. The second metric is a somewhat similar looking relativistic metric with the energy as the arc length. This is the same requirement that occurs in thermodynamics where the change of entropy does not depend upon how the system changes. It depends only upon the end points while the heat depends upon how the change occurs. Here the distance between two points in the entropy manifold does not depend upon the path, but the distance between the same two points in the energy manifold does depend upon the path.

Recalling Einstein's requirement that the laws of physics be such that they may be written in any coordinate system and Poincaré's belief that the physicist may choose the coordinate system, we should pause for a moment to consider the role of coordinate systems in this new line of thought. The first law is a statement of energy change due to work being done on, or by, the system and one is free to choose the coordinate system with which to describe these work terms. While the first law is a path dependent expression, the second law provides an integrating factor and a function, mechanical entropy, whose change does not depend upon the path. The second law provides a variational principle with which to discover equations of motion and with this variational principle the second law specifies another geometry that the researcher must accept. The geometry of the manifold in which the entropy variational principle operates is not a free choice. Yet it is dependent upon the choice of coordinate system in which the first law was written.

Let us now return to the conclusion reported in the biography earlier concerning Poincaré's belief in the freedom to choose geometry where it was stated, "For this reason he argued that Euclidean geometry would always be preferred by physicists. This, however, has not proved to be correct and experimental evidence now shows clearly that physical space is not Euclidean." When one sees that the laws of physics allows one to choose any geometry they desire, yet the second law specifies a second geometry that must also be used, it presents a different view concerning experimental evidence forcing a conclusion about which geometry is 'correct.' Here we see that Poincaré's belief in the freedom to choose geometry remains correct for all uses of the first law. However, when the principle of increasing mechanical entropy for an isolated system is employed to predict motion, the second law transforms the geometry chosen for use in the first law into a second geometry. All experimental evidence supporting any predictions of the entropy principle would not now lead to the conclusion that physical space was 'not Euclidean.' Rather, the evidence would support the conclusion that while the researcher is free to choose the desired coordinate system for describing physical space, the laws of physics specify how this chosen geometry is transformed into a manifold for the prediction of motion. This solution manifold, as it may be called, is not a statement of physical space, but a statement of how motion is predicted to proceed in the chosen geometry describing physical space.

This situation is similar; in fact it is mathematically identical, to the well-known transformation from the use of Newtonian forces to the determination of motion from Hamilton's Principle and then to the Principle of Least Action. By using Newtonian forces to determine the motion one is clearly specifying the forces and choosing the geometry in which the forces are to be applied. If we transform strictly conservative forces into the Principle of Least Action we necessarily pass through the use of Hamilton's functions. In this transformation we give up the clear view of how the forces determine the motion by pushing or pulling objects around in the chosen space. Instead we obtain a geometry wherein the motion is such that a path of minimum distance between two points is followed. In this case it is as if the motion is carried out in a geometrical manifold where the geometry alone determines the motion and no forces are specified. The geometry controls the motion. However, we know that the forces, and our chosen geometry in which we wrote the forces, established the geometry in which the least action was determined. In this fashion we note that the use of Newtonian forces, Hamilton's Principle and the Principle of Least Action, while all equivalent, give us the ability to talk of forces in a chosen geometry or geometry-controlled motion devoid of forces. By choosing the later we have not forced space to be non-Euclidean; rather, we have chosen to use geometry to determine motion instead of forces.

The above argues that while the researcher has a choice of geometry with which to describe the physical world, the laws of nature specify how this chosen geometry is to be used in predicting phenomena. In this discussion the concept of inertia was not used. However, constant velocity processes were needed. One might well ask, “Constant velocity with respect to what?” Nothing in the statement of the first law specified a velocity reference. How then are we to interpret constant velocity processes? By requiring a unique, fundamental limiting velocity the second law has specified the reference velocity. Every observer may now compare velocities with this absolute velocity. The concept of inertia did not arise.

Thus far we have found support for Poincaré’s belief in geometry at the same time we have seen that the fundamental thermodynamic laws require Einstein’s assumption concerning the constancy of the speed of light. Next, in order to investigate the need for an ether, we need to look into how, if at all, these laws describe the propagation of light.

The laws require the energy geometry, the geometry chosen for the path dependent first law description, to have a transformation to a path independent geometry of the entropy manifold. This geometrical transformation, that may now be seen to be a geometrical integrating factor, was first developed by Weyl in 1918[3] when he proposed this geometry as a means to unify the electromagnetic and the gravitational fields in terms of the gauge fields that appeared within the geometry. The geometrical integrating factor showed up as a scale factor. Weyl, therefore, called this function the gauge function as it specified the scale, or gauge, of lengths within the manifold. Einstein argued the path dependence of Weyl’s geometry differed from experience with the result that Weyl’s thoughts were abandoned so far as they went toward any unification of forces.

We see now that the first law requires the path dependence. We now must look into the predictions of the path independent entropy manifold before considering Einstein’s argument on experimental evidence.

In 1922 Schrödinger noticed that should one require a unity scale in a Weyl space then only Bohr’s quantized paths were allowed[4]. Schrödinger went on to develop his wave equations of quantum mechanics in 1926. In 1927 London showed that the requirement of unity scale, in a Weyl space, could only be satisfied by paths that obeyed Schrödinger wave equations[5]. In essence, the requirement of a unity scale factor is the requirement to consider only null-trajectories in the entropy manifold. That is to say, there is no change of entropy, or that along such paths entropy remains constant or, perhaps more illuminating, entropy must return to its original value upon completing a closed path. Further, London showed that Schrödinger’s wave function was proportional to Weyl’s scale factor. By the above argument, this is equivalent to showing that the Schrödinger wave function is proportional to the mechanical entropy as the mechanical entropy is Weyl’s scale factor. Further, since the mechanical entropy is the arc length of the metric for the entropy manifold, this result shows that Schrödinger’s wave equations specify null trajectories in the entropy manifold.

Now let us reconsider Einstein’s argument against Weyl’s proposed geometry wherein Einstein thought the path independence of properties of the atom to be a statement against Weyl’s path dependent manifold. He had not yet had the opportunity to see the result of the work of Schrödinger and London. In retrospect, we have the benefit of reviewing their work and the knowledge that constant entropy is the greatest statement of stability that may be made. Further, we now see that the paths the atoms must follow in the Weyl manifold are only constant entropy paths.

Weyl seized upon London’s result and raised his scale factor to the level of a principle, referred to as Weyl’s gauge principle. This together with Weyl’s earlier display that the gauge potentials, which formed the scale factor in his geometry, led to the Maxwell equations and the resulting electromagnetic gauge fields, provides the basis for all the subsequent gauge field work and includes the work that has followed in the search of a description of the weak and the strong nuclear forces.

This sequence of discoveries in the early 1900’s provides for a description of the propagation of light. This sequence may be summarized as; the first and second laws require that two geometrical manifolds are necessary in order to describe physical phenomena obeying these laws. One manifold, the energy manifold, is tied to second manifold, the entropy manifold, by a geometrical integrating factor that established the scale, or gauge, of the entropy manifold. The tendency of the scale, or gauge, of the entropy manifold to change, or remain fixed, must obey Maxwell's gauge field equations. These field equations, of course, describe the propagation of light that must travel at the unique, absolute velocity specified by the second law.

We now have arrived at the prediction of the propagation of light and relativistic transformations without resorting to forces or the concept of inertia. In the process of discovering how electromagnetic waves may be predicted from the first and second law of thermodynamics, we have also stumbled across the foundations of the field of modern physics based upon Schrödinger's wave equations. Light, or electromagnetic energy, does not need a mechanical medium to support its propagation in this description. Rather, electromagnetic energy is transported through space as the result of a wave-like variation of the scale, or entropy, in the entropy manifold.

The newness of such a concept makes this statement; even if it were correct, appear devoid of meaning. Have we not traded the mechanically based ether concept of a propagation-supporting medium for an even more illusive concept of waving mechanical entropy? Why should one bother with this replacement of a virtually indemonstrable medium with such an inconceivable new one, as this appears to be? Perhaps we should consider these concepts a little further. The ether was thought of being a medium made up of matter that filled space so that this matter might carry the propagation of light in a manner similar to that by which sound waves are moved through air. Molecules of air are moved closer together in compression and then separated by expansion to form the passing wave of sound. One may follow the phase of the sound wave by choosing to follow a portion of the wave, say the maximum compression of the molecules, through the medium and find this traveling at the sound speed. On the other hand we here have the concept of mechanical entropy pervading all space, yet when a wave of light propagates through space the local value of this entropy gets successively smaller and then greater so that the complete cycle of the light wave leaves the entropy at the same value as the beginning of the cycle. We might follow the phase of the light wave and find its velocity to be c, the unique, limiting velocity. Looking a little deeper, we find that since London showed that it is the scale of the manifold that is proportional to the entropy we find that the scale changes as the wave of light propagates through space. First, the scale gets smaller, say, wherein matter, if it were present, would find its molecules compressed closer together. An instant later the scale gets larger where the increased scale would have the molecules of any potentially present matter to spread apart. Though matter is not required to be present in the form of molecules of a substance, the passage of a light wave warps the space as it passes just as if the space, in the entropy manifold, itself is the material medium.

The astute reader might say, "Just a minute! You haven't addressed all the consequences of Einstein's special theory of relativity, but you have introduced the founding concept of a limiting velocity. Doesn't that lead to the concept that energy and matter are equivalent? If that is true, and if mechanical entropy is energy that becomes unavailable, then isn't entropy the equivalent of energy and, hence, matter? Doesn't this then argue that, since mechanical entropy is proportional to the gauge, or length measure, of the space, that there is an equivalent matter pervading all space? If this is the case, haven't we just traded to old mechanistic ether concept for a new mechanical entropy concept?" Perhaps.

Let's assess where we are in our critical reexamination of the ether concept in modern physics, astronomy and cosmology. We started with the first two laws of classical thermodynamics as applied to mechanical forces of whatever nature these forces may be, and found that these laws required us to talk of a unique, limiting velocity with which we must compare all other velocity. We also found that these laws produced metrics through the stability conditions and, thereby, specified the geometry that must be used to determine motion in space even though one is free to choose the geometry of the space in which the first law is written. The laws impose a scale upon the geometry and a constant scale provides the foundation for Schrödinger's wave equations that provides the basis for quantum mechanics in modern physics. We also discussed an argument for the replacement of the ether with the gauge, scale, or mechanical entropy of the space. This does not include any statement of how this modern ether concept may play a role in astronomy or cosmology other than the role that may be played by quantum mechanics.

How is gravitation required of the fundamental laws? Suppose one looks into the equations that describe a four dimensional hyper-surface that is embedded into a five dimensional Weyl manifold consisting of the four dimensions of space-time and an unknown, but physically real, fifth dimension. This is somewhat like asking for the description of a sphere, upon whose surface there are only two dimensions, that is embedded into a three dimensional space. The surface of the sphere will be curved even though the surrounding three-dimensional space need not be curved, but may have a Euclidean geometry. Without knowing what the fifth dimension might be, restricting it to be conserved similar to the statement of the conservation of mass provides a restriction that may quickly be explored[2]. The equations for a gauge field produced when only the fifth dimensional gauge potential is non-zero and conservation of the fifth dimension is imposed are seen to be identical in form to the field equations chosen by Einstein as his gravitational field equations in his general theory. Now the determination of the fifth dimension may be seen, for the only physically real property that experimentally satisfies Einstein's equations is gravitating mass! However, in this case we need to keep in mind that gauge fields in the five-dimensional manifold of space, time and mass are transformed, by conservation of mass, into Einstein's vector curvature fields in the four-dimensional manifold of space and time.

Substantiation for this conclusion may be had when one looks at the first law of thermodynamics and includes three spatial work terms plus the thermodynamic work term. The usual manner of writing the thermodynamic work term involves the specific volume. However, the reciprocal of the specific volume is the mass density. Therefore, the fundamental laws allow the mass as a fifth dimension. When this property is conserved, which is the only condition Einstein considered, there are at least three ways these laws describe gravitational phenomena. First, they may be described using the five dimensional gauge field description wherein the electromagnetic and gravitational fields form a single, inductively coupled, electromagnetogravitic gauge field. Secondly, either of the two fundamental metrics for a surface embedded into a manifold may be used. The fundamental metric of the second type produces the Einstein equations. Further, Einstein's principle of the equivalence of inertial and gravitational mass is a further requirement of the fundamental laws and need not be made separately.

Now we may see how our new concept of the ether comes into play when looking at astronomy and cosmology. The mechanical entropy is the gauge of the five-dimensional manifold of space-time-mass and, therefore, the new concept of the ether plays its role in this manifold. However, should we consider only those systems, or circumstances, in which mass is conserved, as Einstein did, we find that the restriction imposed by conservation of mass embeds a four-dimensional manifold of space and time into the five-dimensional manifold. In the four-dimensional manifold of space and time the gravitational field is seen as a vector curvature of the manifold rather than the scale, gauge, or mechanical entropy of the five-dimensional manifold. We see then that conservation of mass provides two manifolds in which to describe gravitational phenomena; one manifold explicitly displays the ether concept while in the other manifold the ether concept has been transformed from a gauge/distance measure to a vector curvature. Therefore, we find that our modern ether may be seen, not only as the five-dimensional manifold gauge/distance measure, but also as the four-dimensional manifold, created by the conservation of mass, as a vector curvature.

Thus, our new ether concept lives on in gravitational descriptions found in astronomy and cosmology.

References:

1. Williams, P.E., “Thermodynamic Basis for the Constancy of the Speed of Light,” Modern Physics Letters A, Vol.12, No. 35 (1997) 2725-2738.
2. Williams, P.E., “Mechanical Entropy and its Implications,” *Entropy* **2001**, *3*, 76-115.
3. H. Weyl, “Space-time-Matter,” 1918.
4. E. Schrödinger, 1922.
5. F. London, , 1927.