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The Arrow of Time in the Dynamic Theory

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THE ARROW OF TIME IN THE DYNAMIC THEORY

by

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ABSTRACT

A newly proposed, and as yet unverified, theory provides new answers to the old questions concerning the symmetry of time in nature. The theory requires an asymmetry in time for systems whose Newtonian or relativistic description is symmetrical. This is accompanied with the prediction that the universe must forever grow older and continually expand and provides new insight on the extreme red shift of quasars.

I. INTRODUCTION

The notion of irreversibility is embodied in the laws of thermodynamics, but is not in the Newton-Einstein laws of motion. Yet mankind has been constantly aware of the relentless march of history that Omar Khayyám expressed in his:

> The moving Finger writes and having writ,
> Moves on; nor all your Piety nor Wit,
> Shall lure it back to cancel half a Line,
> Nor all your tears wash out a Word of it.

Many articles and books have been written on the subject of time symmetry, but still questions remain. The new theory, called the Dynamic Theory, offers a fresh view of the physical world that provides answers to some of the questions.

The Dynamic Theory adopts generalizations of the classical laws of thermodynamics as the basis for a new view of all physical phenomena. To propose that such a set of laws could discribe all physical phenomena may at first seem preposterous, for mechanical systems obey laws of motion, while the thermodynamic laws have not hitherto provided equivalent equations for thermodynamic systems. Other questions could be raised that also tend to imply the proposition to be absurd. However, these implications prove unjustified. It is obvious that, should laws of motion be obtained from generalizations of the classical laws of thermodynamics, the irreversibility so prominent in thermodynamics would also be embodied within these equations.

II. BASIC LAWS

Generalization of the first law of thermodynamics is not difficult; for it is simply the statement of conservation of energy[1] and may be written as

$$\bar{d}E = dU - F_i dx^i \quad ; \quad i = 1, 2, \ldots, n \quad . \tag{1}$$

Here E represents any energy transferred between the system and its surroundings by any means other than expressible by work terms such as $F_i dx^i$. The symbol U stands for the energy of the system and the number of work terms, n, is determined by the number of independent work terms applicable to the system discription.

An important aspect to keep in mind about such a law is that it depends upon the path taken. Such a law by itself could not give rise to equations that could specify a path. Another law is needed. In classical thermodynamics there are different ways of expressing the second law. Those that are expressed in terms of temperature and heat flow appear difficult to generalize. However, the mathematician Caratheodory showed how the second law could be stated in an abstract way that made no reference to a particular system. This statement was adopted as the second law and is;

> In the neighborhood (however close) of any equilibrium state of a system of any number of dynamic coordinates, there exists states that cannot be reached by reversible E-conservative ($\bar{d}E = o$) processes.

It is this law that houses the notion of irreversibility. If applied to all systems, then the irreversibility of thermodynamics is a fundamental property of all systems. To show that such a law does apply to all systems, we first need to show how it can produce Newton-Einstein equations of motion.

First, let's consider some of the immediate results of adopting these two laws. The second law has no restrictions on the number of independent variables needed to describe a system's behavior. It is not too difficult to show that[1], regardless of what system may be imagined, the second law guarantees the existence of an integrating factor for the first law. The integrating factor is independent of the system and hence is applicable to all systems.

The existence of an integrating factor for the first law guarantees the existence of a differential form

$$dS = \frac{\bar{d}E}{\Phi} \quad , \tag{2}$$

where the integrating factor is $\frac{1}{\Phi}$ and the symbol S stands for the generalized entropy. Obviously, the existence of a generalized entropy expands the notion of thermodynamic entropy to include any system discribable by the statement of conservation of energy. If we desire to consider only the mechanical properties of a system, as we usually do when using Newton-Einstein equations of motion, then the second law guarantees the existence of a "mechanical entropy."

The concept of mechanical entropy may be new, but it may be used to shed an entirely new light upon the behavior of mechanical systems. In particular, it is the mechanical entropy that provides a new view of time asymmetry for mechanical systems. Further, since we need to show how equations of motion can come from the adoption of these laws, we shall restrict our systems to be mechanical ones. Obviously, if we restricted ourselves to purely thermodynamic systems, these laws would produce classical thermodynamics. Also, having shown that we can obtain equations of motion for mechanical systems, we may retrace our steps and obtain equations of motion for thermodynamic systems; however, this would lead us too far from the present theme.

Restricting our attention to strictly mechanical systems, we find another immediate result of the second law. Namely, the integrating factor, $\frac{1}{\Phi}$, is strictly a function of velocity. This leads to the existence of a unique velocity that drives the integrating factor to infinity, or in other words, where the function Φ becomes zero. This is identical with the existence of an absolute zero temperature in thermodynamics. Further, it may be shown that the unique velocity is the speed of light, c, and Einstein's postulate concerning the constancy of the speed of light follows immediately.

The first and second laws cannot compare the mechanical entropy of one system with the mechanical entropy of another. This is the same situation that occurs in the thermodynamic case where it becomes necessary to have another, or third, law. A generalization of this law, making it applicable to all systems is;

> The generalized entropy of the system, when the integrating factor, $\frac{1}{\Phi}$, becomes infinite, is a constant and may be taken to be zero.

If we now impose this law, together with the other two, upon our mechanical system, we find that if our system has a velocity less than the unique velocity, the speed of light, the velocity may never exceed this velocity. This is reminiscent of relativity theory. Indeed it can be shown that such is the case; however, to do so would again be straying too far afield.

III. EQUATIONS OF MOTION AND GEOMETRY

Having established the fundamental laws, we need to address the question of laws of motion, for if these laws cannot produce equations of motion, we have made no real theoretical advance. Let us again restrict our attention to mechanical systems. It may be shown, indeed it should be obvious, that if the system is isolated, $\bar{d}E = o$, then the second law produces a principle of never decreasing mechanical entropy, or

$$dS \geq o \quad , \tag{3}$$

when

$$\bar{d}E = o \quad . \tag{4}$$

This is the principle that will produce the mechanical arrow of time, but we are getting ahead of ourselves.

Newton assumed that the geometry of the universe to be Euclidean. Einstein assumed it to be Riemannian. Must the type of geometry be assumed here also? It would certainly help things if nature would be so kind as to remove the necessity of making an assumption concerning the geometry by telling us what it should be. Can these laws do that? If they can produce equations of motion they ought also to be able to specify the geometry underlying this motion.

By appealing to the mathematics of functions of several variables, we find that the quadratic form for maximizing, or minimizing, a function of several variables becomes a natural metric discribing "distances." The second law, through the stability conditions, provides us with just such a quadratic form. However, we find that instead of only one quadratic form, the stability conditions produces several depending upon the choice of independent variables. Though the second law produces an apparent choice of quadratic forms, it selects a single form by imposing the principle of mechanical entropy.

The mechanical entropy principle becomes the variational principle and the metric is one whose arc length is the mechanical entropy, which may be written in terms of the specific mechanical entropy as

$$(dq^o)^2 = \hat{g}_{ij} dx^i dx^j \quad ; \quad i, j = o, 1, 2, 3 \quad , \tag{5}$$

where $x^o = ct$, c is the speed of light and the unique velocity of the second law, and q^o is the specific mechanical entropy.

The second law is not through yet, for it produces another metric related to this one and is given by

$$(dq^o)^2 = \hat{g}_{ij} dx^i dx^j = f(g_{ij} dx^i dx^j) = f(d\sigma)^2 \quad . \tag{6}$$

This additional metric, at first, seems to cloud the issue, but when we seek to find whether the laws also specify the type of geometry for each of these spaces, we obtain the answer, "yes!" It may be shown that the "entropy" space, $(dq^o)^2$, must be a Riemannian space, while the "sigma" space, $(d\sigma)^2$, is a Weyl space. With the determination of the geometry, the appearance of two related metrics provides added capabilities for the theory, as we shall see.

IV. CORRESPONDENCE WITH CLASSICAL THEORIES

The three adopted laws, together with the restrictive assumption $\bar{d}E = o$, not only produce equations of motion (geodesics in the entropy space), but they also specify the geometry. This removes the necessity of making an additional assumption as Newton and Einstein were required to do. Further, the appearance of the gauge function f, which couples the entropy space and the sigma space, is the analog, in differential geometry, to the integrating factor coupling the differential change in entropy to the first law. Also, once the entropy principle is imposed, the set of conditions set up by Weyl in his unified theory is completed and we may refer to his work[2] to show how variations of the gauge function produces Maxwell's electromagnetism, while variations of the metric coefficients, g_{ij}, produces Einstein's General Relativity. Obviously, allowing the coefficients to become constants will produce special relativity.

The preceeding has outlined how the adopted laws produce the relativistic theories, electromagnetism, and classical thermodynamics, but has not discussed nuclear or quantum effects. Though it may be going off the main path a little, we may quickly show how the theory produces quantum effects by pointing out that the mechanical entropy principle states that the entropy may never decrease. This leaves two possibilities; either the entropy is increasing or it remains fixed. If the process is irreversible, the entropy must increase. A reversible process is one that the entropy remains fixed. Obviously, if the entropy is fixed, then the equations of motion, in the entropy space, becomes null trajectories. London showed[3], in 1927, that this condition produces quantization within the coupled metrics. From the mathematics of complex variables, the fundamental quantum number specifies the "order" of the null trajectory just as poles and zeros have order.

V. ARROW OF TIME

A discussion of how nuclear forces appear within the theory will not be presented, for the foregoing sets forth all that is necessary to show how the theory addresses the arrow of time.

The mechanical entropy, q^o, is related to the relativistic proper time by

$$dq^o = c d\tau \quad . \tag{7}$$

The entropy principle requires that this differential change of proper time never be negative for an isolated, $\bar{d}E = o$, system. Further, any system that is the least bit irreversible must forever be growing older. The range of implications of this principle may be obvious; however, no attempt will be made here to explore all of these implications.

The mechanical entropy principle has significant implications on cosmology. First, the universe, as an isolated system, must be getting older if there are any irreversibilities within it. Thus, it may also be inferred that if the mechanical entropy, which is a measure of "distance" in the entropy space, is forever increasing, then the scale of the universe must be forever increasing. In other words, the universe must be forever expanding, thus ruling out cosmological models that would have the universe contracting at some future time.

The above conclusions about an expanding universe does not necessarily imply that light received from every star or galaxy within the universe display a red shift. It must be remembered that the entropy principle can be applied only to isolated systems. Thus, it must be considered possible for an individual star to interact with the rest of the universe in such a way as to produce a blue shift. The probability of a blue shift based upon a decreasing scale factor in a local region of the universe must be considered small in the light of irreversibility. On the other hand, if the red shift is a measure of irreversibility to be added to the gravitational red shift, then the large values of red shift for quasars may be viewed in an entirely new light. This would imply that the processes going on within quasars are more irreversible than the processes within other stars.

Another implication of the mechanical entropy principle applies to the comparison of age of any part of the universe to the age of the universe as a whole. The mechanical entropy of an isolated system, say the universe, must increase and represents the age of that system. This age is based upon the irreversibility of that system. However, individual parts of the universe may, through interaction with the other parts, age faster or slower than the universe as a whole. Thus, the dating of a geological formation resulting in a date exceeding the supposed age of the universe would not necessarily be an inconsistency.

It might be interesting to point out that within the context of the Dynamic Theory, there may still be a slight probability that mankind may be able to find Ponce de Leon's fountain of youth. Suppose that man is considered as the system in question. Then, if the man is isolated from the rest of the universe, he must grow older. However, there may be a particular set of interactions between the man and the rest of the universe that would allow time for the man to slow down; perhaps even reverse. This would be the same situation in thermodynamics where the entropy of a system is made to decrease by an appropriate transfer of heat.

What happens to the thermodynamic prediction that the universe will end in a death of fire? If indeed the Dynamic Theory represents a description of nature, the increase in generalized entropy may result in increased mechanical entropy, or expansion of the universe, thus removing the necessity of increasing thermodynamic entropy and a death by fire.

VI. REFERENCES

1. P. E. Williams, "The Dynamic Theory: A New View of Space, Time, and Matter," Los Alamos Scientific Laboratory report LA-8370-MS (December 1980).

2. H. Weyl, "Space-Time-Matter," 1922.

3. F. London, "Quantum Mechanische Deulung der Theorie, Von Weyl," z, Physik 42: 375-389, 1927.

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