RELATIVITY AND CLASSICAL PHYSICS

by
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That classical physics can be easily extended to produce results originally derived by Einstein's general theory of relativity, but with ordinary concepts of space and time, in shown in this concise paper written by Theodore Theodorsen, the head theorist at N.A.C.A. (forerunner of NASA) in the heady days when aeronautics evolved from a very primitive art into a full-fledged science. A physicist, and long-time skeptic about Einstein theory, he sought and developed explanations to replace those involving curved spacetime and abstract mathematical fields. In essence, Newtonian theory is modified by only a "quantum" change to yield Einstein's results. We are very grateful to Muriel T. Williams for presenting us with her father's manuscript.

INTRODUCTION

Prominent scientists have suspected for a long time that General Relativity was based on certain fallacious basic concepts. In 1927 Eddington wrote in the conclusion of his **Nature of the Physical World**: "Can we guarantee that the next thirty years will not see another revolution, perhaps even a complete reaction?" This prophesy has been belatedly confirmed by this writer after a successful transformation of the theory of relativity into classical physics which is presented here. The mathematical entities of the Einstein development have been redefined into rational physical quantities and rearranged in an organized classical framework. Einstein's "space-time" has been eliminated and replaced by ordinary (conscious) time.

The theory of General Relativity was accepted originally almost exclusively on the basis of the accurate but actually fortuitous predictions of the behavior of the planet Mercury and the deflection of light near the Sun. Since its inception no consequential developments have ever occurred and no relationship or applications to other fields of physics have been established.

The writer long ago noticed fallacies in the statements of Eddington and others and after years of attempts to disentangle the matter was finally able to uncover the key to the solution of the problem of relativity in its relation to classical physics. It was then possible to write down new relationships based on the classical three dimensional space with time as a separate and independent variable.

In contrast to the method of relativity, in the present work, forces and masses are not abandoned in favor of mathematical fields, curvatures of space and artificial time. The amazing simplicity of physical relationships in the gravitational field of the Sun (or of any massive body) revealed in this report, is the clue to the quantitative agreement between the results of this classical treatment and those of General Relativity.

The writer would, however, probably not have arrived at these amazingly simple solutions if it were not for the previous existence of the Lorentz and Einstein mathematical models which made the physical interpretation of the mathematical equivalents possible.

With the introduction in the present paper of the concept of the tensor quality of mass, the mass-energy relation is no longer in the simple scalar form $E = mc^2$ except in simple cases. This expression is necessarily generalized to tensor form to comply with the ellipsoidal tensor representation of gravitational fields. With the tensor form of the mass-energy relation and the calculus of variations it is shown in this paper that the geodesic of a light ray is readily obtained. It is shown that this may also be obtained by a method using the mass-energy relation and the law of the constancy of the angular momentum. The orbit of the planet Mercury is calculated by use of the relation and the laws of conservation of energy and of the constancy of the angular momentum. Further the velocity addition theorem is also obtained with great simplicity by using merely Newton's law on action and reaction.

While Einstein was not aware of the tensor quality of mass, he inadvertently but correctly adjusted any associated velocity by the device of introducing the compensating (slower running) "space-time". This time as compared to classical or conventional time, runs differently in different directions and at different velocities, and is thus almost impossible to visualize. This "new concept of thought" and other artifices of relativity resulted in great confusion as to the properties of the real world and seemed to invalidate in many ways the classical concepts.

With the disentanglement of the "new concepts of thought" of relativity it is now possible to prescribe extensions of the classical laws governing the velocity of light and the laws of gravitation. This theory also stipulates a universal reference frame relative to which all absolute velocities must be measured. *The extremely small body of test data, some of it even rather inconclusive, which are considered as proof of the validity of the relativity theory must be regarded also as proof of the validity of this one as the quantitative results agree with those of relativity. Further, this theory because it retains the classical concepts, is subject to verification in other ways, whereas that of Einstein apparently is not, as convincing proofs are yet to be demonstrated.*

PROPULSION BY EXTERNALLY AND INTERNALLY PRODUCED FORCES: THE TWO MASS-VELOCITY RELATIONS

There are two different cases of propulsion considered in the following. If the source of the energy supply is *external to* the body we shall term it Case I; *if internal*, we shall term it Case II. In Case I the mass increases as energy is supplied to the body from the outside, but in Case II even as the velocity is increasing, the mass of the body remains constant as will be shown.

Using conventional nomenclature one has for Case I

$$Fdt = d(mv)$$

The energy supplied from the source is then

$$dE = Fvdt = Fds = vd(mv)$$

and by the mass-energy relation

$$Fvdt = Fds = c^2 dm$$

Thus also

$$c^2 dm = vd(mv)$$

Multiplying by m on both sides and integrating one has

$$\boxed{m = m_0 \frac{1}{\sqrt{1-(v/c)^2}}} \tag{1}$$

where m_0 is the value of the mass at v = zero. *This is the well known relativity expression for the increase in mass with velocity.* It is, however, valid only *if and when the propulsive force is externally produced.* An electron exposed to the force of an electrostatic field is a typical example.

We shall next consider Case II, that of internal propulsion. An example is, for instance, a train on a horizontal track propelled by a battery inside the train. Let us consider the absolute magnitudes involved. One has as above

$$|Fdt| = |d(mv)|$$

But if

$$m = m_0 = \text{constant}$$

one has then $\quad |Fdt| = |m_0 dv|$

and $\quad |Fvdt| = |m_0 v dv|$

On the left side of this equation is an element of the energy extracted from the battery and on the right side is the element of the corresponding velocity energy. The two elements are therefore equal but of opposite sign. Consequently the mass of the train remains the same as postulated above: $m = m_0$

For the velocity energy[1] of the train there is simply, by integration

$$E_v = m_0 \int v dv = \frac{1}{2} m_0 v^2 = \frac{1}{2} E_0 (v/c)^2 \tag{2}$$

This is the fundamentally important formula for the energy in Case II. The velocity energy is exactly $E = \frac{1}{2} m_0 v^2$ *if and when the propulsive force is produced by internal conversion of energy.*

The importance of this Case II formula is that it applies to massive bodies and light particles in space: static energy is converted into velocity energy and vice versa. Thus the total energy is constant.

With the total energy equal to E_0, one has therefore:

$$E_0 = E_S + E_0 \frac{1}{2}\left(\frac{v}{c}\right)^2 \tag{3}$$

and thus for the static energy,

$$E_s = E_0 \left\{1 - \frac{1}{2}\left(\frac{v}{c}\right)^2\right\}$$

Both Cases I and II are developed here in compliance with classical physics. *As shown, mass does not in certain cases increase with velocity, and the statement from relativity that "mass increases with velocity" must therefore be qualified in accordance with the presentation here.*

REDEFINITION OF THE MASS-ENERGY RELATION

It should be noted here that while the expression $E = mc^2$ was for all practical purposes introduced into physics by Einstein in his famous paper on special relativity (1905), this relation nevertheless stands *independent of any theory* as a concrete physical law. This is generally overlooked by most physicists.[2]

In the previous pages we have employed the relation $E = mc^2$ in its original scalar form because this is applicable in cases where the variability of the velocity of light is of no concern. However, in other cases such as the calculation of the orbit of Mercury or the determination of the geodesic of a light ray where this variation is the essence of the problem, the tensor form of the relation must be employed.

The relation now may be written

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[1] The terms static and velocity energy instead of the more usual terms potential and kinetic energy are intentionally employed. The reason for this terminology will become apparent from the text.

[2] In an experiment with radiation in 1904, a physicist named Hasenöhrl showed that radiation behaved as though it had mass = e/c^2, where e is the electromagnetic energy, and c is the speed of light. [p. 56 of Ref. 7].

$$E_0 = m_s c_s^2 \tag{4}$$

where the subscript s refers to any direction with respect to the Sun (or any appropriate massive body).

The mass m_s is represented by an ellipsoidal tensor and c_s^2 by the inverse tensor. These tensors vary in magnitude with the distance from the Sun (or appropriate massive body). The product of the tensors is of course an invariant scalar E_O which is the same in all directions. In the following we shall make use of this extended tensor form of the mass-energy relation.

THE GEODESIC OF A LIGHT RAY

a. Method of the Calculus of Variations

It is postulated that the energy of a light particle remains constant in space. Using angular coordinates r and ϕ with respect to the Sun, let us write

$$E_0 = m_r v_r^2 + m_\phi v_\phi^2$$

For simplicity we shall put E_0 equal to unity. One has then

$$\left(\frac{v_r}{c_r}\right)^2 + \left(\frac{v_\phi}{c_\phi}\right)^2 = 1 \tag{5}$$

The light velocities c_r and c_ϕ are inherent properties of the Continuum; v_r and v_ϕ are the instantaneous components in the radial and the tangential directions. It may be seen (page 349, reference 7) that

$$c_r^2 = \frac{c_\infty^2}{K_r} \tag{6}$$

$$c_\phi^2 = \frac{c_\infty^2}{K_\phi} \tag{7}$$

where K_r and K_ϕ are the principal dielectric constants of the medium with $K_\infty = 1$.

Thus c_r^2 and c_ϕ^2 are inversely proportional to the terms K_r and K_ϕ. In the following, light velocity is given in nondimensional form in terms of the velocity at infinity ($c_\infty = 1$) unless otherwise evident. In angular coordinates one has

$$v_r = \frac{dr}{dt} = \dot\phi \frac{dr}{d\phi}$$

and

$$v_\phi = r\dot\phi$$

where $\dot\phi = d\phi / dt$. The equation (5) then reads

$$\left\{\frac{1}{c_r^2}\left(\frac{dr}{d\phi}\right)^2 + \frac{1}{c_\phi^2} r^2\right\} \dot\phi^2 = 1 \tag{8}$$

With F defined as the square root of the quantity in the brackets, we may write

$$F d\phi = dt$$

We may now employ the calculus of variations in conventional manner to obtain the shortest path of a light ray.

With

$$\int_0^\phi F d\phi = t - t_0$$

the shortest path is then obtained by the solution of the equation

$$\frac{\partial F}{\partial u} = \frac{d}{d\phi}\frac{\partial F}{\partial \dot u} \tag{9}$$

where

$$u = \frac{1}{r}, \qquad \dot u = \frac{du}{d\phi}, \qquad \ddot u = \frac{d^2 u}{d\phi^2}$$

After performing the indicated differentiations of the function F (see Appendix I) one obtains the relation

$$\ddot u - \frac{1}{2}\dot u^2 \frac{d}{du} \ln\left(\frac{c_r}{c_\phi^2}\right)^2 = -\frac{1}{2}\left(\frac{c_r}{c_\phi^2}\right)^2 \frac{d}{du}\left(c_\phi^2 u^2\right) \tag{10}$$

This is the all inclusive mathematical solution of the problem of the geodesic. It contains not only the Newtonian solution for a scalar field but also the relativity solution as obtained by Schwartzchild. The solution is valid for any and all possible values of the light velocities.

Next we shall show how the identical solution is readily obtained by applying the physical law of the constancy of the angular momentum. The relation between this law and the geodesic is of fundamental interest.

b. Method of Constant Angular Momentum

Next let us introduce the physical restriction of a constant angular momentum. In classical physics one has

$$h = \frac{1}{c_\phi^2} r^2 \dot\phi \tag{11}$$

where $1/c_\phi^2$ is the tangential component of the mass tensor representing a particle of energy $E_0 = 1$, and $r\dot\phi$ is the tangential velocity. (In relativity $h = \infty$, reference 3)

Introducing the angular momentum h into equation (8) one has with $u = 1/r$, $\dot u = du / d\phi$, $\ddot u = \dfrac{d^2 u}{d\phi^2}$

$$\left(\frac{c_\phi^2}{c_r}\right)^2 \dot{u}^2 + c_\phi^2 u^2 = \frac{1}{h^2}$$

By differentiation with respect to ϕ one obtains

$$\ddot{u} - \frac{1}{2}\dot{u}^2 \frac{d}{du}\ln\left(\frac{c_r}{c_\phi^2}\right)^2 = -\frac{1}{2}\left(\frac{c_r}{c_\phi^2}\right)^2 \frac{d}{du}\left(c_\phi^2 u^2\right) \qquad (12)$$

Thus the mathematical condition for the shortest path is perfectly equivalent to the physical restriction on the angular momentum. In other words, a light ray obeying the law on the angular momentum automatically traces the shortest path.

c. *Derivation of Einstein's and Newton's Expression from Equation (10) or (12)*

If in this equation (10) or (12) the values of the light velocities were known the path would be established. The variations are, however, small, in the order of 10^{-8} at the orbit of Mercury, for instance.

Using Newton's scalar field with $c_r = c_\phi =$ Unity, one gets directly from the equations (10) or (12)

$$\ddot{u} + \dot{u} = 0 \qquad (13)$$

This is the relation for a straight line in angular coordinates. The next simplest field of radial symmetry is an ellipsoidal tensor field. This field is due to the effect of the Sun's gravitational force on the Continuum. Employing the somewhat radical assumption of a Continuum that is "solid" rather than "ethereal", for the respective stress components, one gets the tensor elements

$$\tau_r = \left(1 - \frac{k}{r}\right)^2 \text{ and } \tau_\phi = 1 - \frac{k}{r} \quad \text{(See Appendix II)}$$

where $1/r = u$ and k is an integration constant.

In view of the relations (6) and (7) one has then the equalities

$$c_r^2 = \frac{1}{K_r} = \tau_r = \left(1 - \frac{k}{r}\right)^2 \qquad (14)$$

and

$$c_\phi^2 = \frac{1}{K_\phi} = \tau_\phi = 1 - \frac{k}{r} \qquad (15)$$

where the expressions are all given with respect to their values at infinity, c_∞, K_∞, τ_∞ , or these quantities put equal to one. The Continuum thus exhibits these surprisingly simple relationships between the dielectric constant, the stress tensor and the square of the light velocity. The dielectric constant is seen to be inversely proportional to the gravitational stress tensor. This could be no accidental coincidence, but is evidently a significant physical fact. It is thus seen that the gravitational fields play a dominant role in the properties of the Continuum. This becomes more obvious as will be shown later. The reference frame referred to later is also related directly to the gravitational fields.

The light velocities c_r and c_ϕ were introduced at the beginning of the development and the quantitative values established only at the end. The "disturbing" term with $\dot{u}^2$ is eliminated in consequence of the relations (14) and (15) regardless of the value of the constant k as the term $c_r / c_\phi^2 = 1$. It seems then that the Continuum must be so constructed that the term with $\dot{u}^2$ is equal to zero with mathematical perfection and therefore no effect of this "disturbing" term has been observed.

When the value of k is put equal to $2m$ to comply with the known physical relations, equations (17) and (23), the value of

$$c_\phi^2 = 1 - \frac{2m}{r} \text{ and } c_r^2 = \left(1 - \frac{2m}{r}\right)^2 .$$

We insert these values in the equations (10) and (12) and obtain

$$\ddot{u} = -\frac{1}{2}\frac{d}{du}\left\{(1 - 2mu)u^2\right\} \qquad (16)$$

or

$$\boxed{\ddot{u} + u = 3mu^2} \qquad (17)$$

where m is the mass of the Sun given in astronomical units as employed in reference (3).

and

$$m = G\frac{m_1}{c^2} \qquad (18)$$

where G is Newton's constant, m_1 the solar mass in cgs units, and c the velocity of light at infinity. The numerical development of equation (17) may be found in reference (3). It gives the angular deflection as 1.75 seconds of arc, in reasonable agreement with observations. It is of interest to note that the numbers 2 and 3 are actual integers in the preceding relations. Note by reference to Case II, that only one-half of the total energy is in the form of velocity energy. *This is in agreement with the statement that the static energy is equal to the velocity energy in cases where the energy for propulsion is internal.*

THE ORBIT OF MERCURY

It is postulated that the energy content of a body in space remains constant in its path of travel. We shall therefore apply Case II, the case of internal propulsion. With E_v and E_s as the velocity energy and the static energy respectively, and with E_0 put equal to unity,

$$E_v = \frac{1}{2}\left\{\left(\frac{v_r}{c_r}\right)^2 + \left(\frac{v_\phi}{c_\phi}\right)^2\right\} + \text{constant} \tag{19}$$

and

$$E_s = -\frac{m}{r} + \text{constant} \tag{20}$$

By addition, the total constant energy is

$$-\frac{m}{r} + \frac{1}{2}\left\{\left(\frac{v_r}{c_r}\right)^2 + \left(\frac{v_\phi}{c_\phi}\right)^2\right\} = \text{constant, or}$$

$$-\frac{2m}{r} + \left(\frac{v_r}{c_r}\right)^2 + \left(\frac{v_\phi}{c_\phi}\right)^2 = \text{constant}$$

In angular coordinates one has

$$-\frac{2m}{r} + \left\{\frac{1}{c_r^2}\left(\frac{dr}{d\phi}\right)^2 + \frac{1}{c_\phi^2}r^2\right\}\dot{\phi}^2 = \text{constant} \tag{21}$$

Eliminating $\dot{\phi}^2$ by means of the relation for the angular momentum, equation (11), one has

$$-\frac{2m}{r} + \left\{\frac{1}{c_r^2}\left(\frac{dr}{d\phi}\right)^2 + \frac{1}{c_\phi^2}r^2\right\}\frac{c_\phi^4}{r^4} = \text{constant}$$

$$-\frac{2m}{rh^2} + \left(\frac{c_\phi^2}{c_r}\right)^2\left(\frac{dr}{d\phi}\right)^2\frac{1}{r^4} + c_\phi^2\frac{1}{r^2} = \text{constant}$$

With $\frac{1}{r} = u$, $\frac{c_\phi^2}{c_r} = 1$, and $c_\phi^2 = 1 - 2mu = \gamma$, one gets

$$\frac{1}{h^2}\gamma + \left(\frac{du}{d\phi}\right)^2 + \gamma u^2 = \text{constant} \tag{22}$$

By differentiation with respect to ϕ and eliminating $du/d\phi$ there is

$$\boxed{\ddot{u} + u = \frac{m}{h^2} + 3mu^2} \tag{23}$$

This final result is again in agreement with that of the theory of relativity. With the extra term $3mu^2$ omitted one has Newton's formula

$$\ddot{u} + u = \frac{m}{h^2} \tag{24}$$

where the mass m is in astronomical units. (equation 18)

Note that the term c_ϕ^2 appeared in the form $c_\phi^2 = 1 - ku$. It may be verified that only for the value $k = 2m$ is the result in agreement with the known physical facts.

The detailed calculation of the motion of the perihelion of Mercury is given in reference (3). This numerical calculation will for the sake of brevity be omitted here.

The path of a heavy mass is thus obtained here by the method of the constant angular momentum.

THE VELOCITY ADDITION THEOREM

The simplest procedure for obtaining this is by employing the method of Case II. Let us assume we have an object equipped with an internal compressed spring. The energy in the compressed spring would upon release propel the body as a rocket. In compliance with Case II the mass m_0 includes the mass of the object, of the spring, *and the energy of the compressed spring.*

We stipulate that the hypothetical dual-function spring is capable of delivering the same total impulse to the object whether the object be fired off from a state of rest or while the object is in a state of unaccelerated motion. If fired from a state of rest the impulse would be

$$\int F dt = m_0 v$$

If fired while in a state of unaccelerated motion, the impulse delivered would be of the same value. Consequently the momentum would also have the same value, though the mass and velocity would both have new and different values. Their product would nevertheless be equal to the product $m_0 v$.

Now let us assume that we have some sort of platform equipped with an attached vertical section to serve as a backstop. Let us place our test object, with its spring compressed, on the platform with the spring against the backstop. Let us now give the platform with the test object on it a velocity of w. One realizes that if one were to release the compressive force of the spring against the backstop to give more forward velocity to the test object, the reactive impulse would push the backstop and the attached platform rearwards with the full momentum $m_0 v$. In order to maintain the forward velocity of the backstop-platform when the spring is fired, an equivalent momentum must be provided behind it. The state of motion of the platform will then remain unaltered, and the energy supplied for this purpose will go directly into the test object to increase its velocity. This added energy is then

$$E = w\int F dt = w m_0 v$$

This energy is added to the original energy $m_0 c^2$ of the object at rest with the spring compressed, and one has for the total energy

$$E_T = m_0 c^2 + m_0 wv \tag{25}$$

and the mass is increased to

$$m = m_0\left(1 + \frac{wv}{c^2}\right) \tag{26}$$

Since the two constant momenta can be added according to classical physics, one has, by addition, for the total momentum

$$M_T = m_0 w + m_0 v = m_0 (w + v)$$

and for the mass as shown in equation (26)

$$m = m_0\left(1 + \frac{wv}{c^2}\right)$$

Thus for the resulting velocity, by division

$$\boxed{V = \frac{w + v}{1 + wv / c^2}} \tag{27}$$

From the foregoing it is apparent that *velocity has no separate and independent status. It is always the ratio of momentum and the associated mass.*

For the Fizeau case the velocity $v = c/\eta$ is the light velocity in a fluid medium of index η. One has

$$v = \frac{w + c / \eta}{1 + w / (\eta c)} \tag{28}$$

For the limiting case $\eta = 1$, there is

$$v = \frac{w + c}{1 + w / c} = c \tag{29}$$

For an observer on a raft floating on a fluid with velocity w in the same direction as c, the velocity of light is $c - w$, in contradiction to the findings of the theory of relativity. This is a simple case of comparison of two velocities in accordance with classical theory. Both velocities are subject to measurement by means of ordinary clocks and measuring rods.

PRINCIPAL CONCLUSIONS

Many useful conclusions may be drawn from the foregoing material, but perhaps the most important ones are in regard to light and gravitation. Presently the velocity of light is classified as a "constant of nature",[3] but as has been shown in this work, the velocity of light is not constant except under circumstances where there is no gravitational force.

The fundamental *laws of the propagation* of light are proposed and presented here as follows.

First Law: Universal Reference Frame — *The universal reference frame is an orthogonal system composed of the equipotential surfaces surrounding all masses in the Universe and the gradient lines of the gravitation potential extending from their centers into space.*

Second Law: Magnitude of the Light Vector — *The velocity of light with respect to points of the universal reference frame is a function of the potential of gravitation and the angle of the velocity vector with the gradient of the potential at any instant of time. The velocity of light obeys the laws of the propagation of light in a non-isotropic medium.*

Third Law: Earth's Reference Frame — *The equipotential surface surrounding the Earth and its gravitational gradient lines comprise the reference frame. The gradient lines of the Earth move with it in translation, but not in rotation, as the frame is stationary or fixed with respect to a radial line from the center of the Earth to the center of the Sun.*

It is pertinent to note here that the motion of the surface of the Earth relative to the reference frame is apparently far too small to have a detectable (by present day technology) effect on electromagnetic phenomena. This is the reason why Maxwell's equations appear to be exactly true.

The universal reference frame is permanently anchored to all the masses in the Universe, but may be considered stationary in empty space.

It is actually in a state of continuous distortion as it is everywhere attached to the stars and planets *etc.*, which are moving. But the relative distortions are of almost minute magnitude since the velocities of the bodies are small compared with the velocity of light. The lines of the frame or lines of the gravitational potential are crowded together in front of the advancing side of a body, and more sparsely spaced near the opposite side or in the "wake" of a body. In consequence, a light ray emanating from the advance side of a planet, for instance, immediately reduces its velocity in response to local conditions while on the back or "wake" side, the light ray increases its velocity in response to those local conditions.

The Earth and its reference frame or gravitational potential system which extends some million kilometers into space, and which is fixed with respect to a radial line from the Earth to the center of the Sun, revolves around the Sun in its potential system which in turn is stationary with respect to a radial line from the Sun to the center of the Milky Way, and so on. Though the Earth and its potential system move together in translation, the Earth rotates relative to its potential system. At the surface of the Earth the velocity of light as measured with respect to the reference frame in the east direction will be different from that in the west direction by somewhat less than one km./sec. No experiment adequate to detect this has

[3] The **Smithsonian Physical Tables**.

yet been devised.[4] On or in the vicinity of the Earth the field of gravitation potential includes the field of the Sun, the self-generated field of the Earth, and the effective field due to the centrifugal force. The balancing influence of the latter partially nullifies the effect of the field of the Sun. But both field effects are so small that the Earth appears as if it were alone in space.

The maximum value of the velocity of light in the solar system occurs at "infinity" with respect to the Sun where the potential is maximum also.

In regard to the laws of gravitation, *particles of light are not subject to mutual attraction or to the attraction of massive bodies, but are governed exclusively by the laws of transmission of light in an anisotropic medium.* The anisotropy is caused by the strain system of the gravitational fields.

Newton's Law of Gravitation applies to massive bodies (of constant energy content) but it does not give the total effect. A second law relates exclusively to motion in space, and I therefore propose the laws of gravitation to be stated as follows:

First Law: *This is Newton's law of gravitation, applicable to massive bodies whether in motion or not.*

Second Law: *Massive bodies in motion are additionally subject to, and particles of light are exclusively subject to, the classical laws of transmission of electromagnetic waves in an anisotropic medium.*

THE CONTINUUM

This is the picture of the Universe as I see it as a result of my investigations. The Continuum, the "old" ether, may be the real substance from which all Creation is made. At the beginning of the century, atoms were judged to be indivisible solid particles, and the Continuum to be almost ethereal. Some decades later it was known that the atoms themselves were not only divisible, but in fact, almost empty. With the quantum theory, it became evident that even the remaining singularities, the protons and electrons were merely vibratory entities in the Continuum. We know that light waves and these vibratory structures are electromagnetic in nature, but the mathematical solution and the physical explanation for the various elementary particles are still in the future.

From my investigations I believe the following statements to be true: The Continuum is composed of a substance of enormous rigidity, with a very high modulus of elasticity. This conclusion is based on the fact that there is no observable time delay in the transmission of the gravitational force. Newton, and Einstein and the present writer all give no allowance for time delay: Observations seem to be in agreement with this. In consequence of the apparent enormous rigidity there can be no appreciable energy stored in the Continuum itself. It seems that a relaxed or strain-free Continuum may have exactly zero energy content. Gravitational strain must by necessity contain some energy, however minute. Thus one may say that the *Continuum materializes under the strain of the gravitational influence.* The gravitational forces are supplied by the internal energy of the gravitating bodies themselves.

The Earth is traveling in the permanent pre-stressed field of the Sun's gravitational force. Therefore, if the centrifugal force due to the Earth's revolution around the Sun were instantly reduced, the Earth would *instantly (with no time delay)* begin to fall towards the Sun in response to the force of the pre-stressed Continuum. If the Earth did not exist and were instantaneously created with its own gravitational strain structure and revolving in its present path, it would take far less than the often quoted eight minutes for equilibrium forces to be attained. Equilibrium would occur almost immediately.

As the Continuum probably contains almost no energy and therefore no mass it may in consequence have a high velocity of any compressional signal. According to classical physics the velocity of the compressional waves must at least be greater, and probably greater by a high order, than that of the light waves. This is a problem of great interest to be solved in the future.

Another property of the Continuum is that there is, of course, no friction or heat conduction whatsoever, not even any electric conductivity. These may be statements of trivial nature, but important for the scientific definition of the substance of the Continuum. Vibratory structures in ordinary cases dissipate, but the structures in the Continuum from which physical matter is made only change in finite steps. These structures lose or gain energy only in the form of electromagnetic waves.

Matter, composed of such vibratory structures, also carries electric charges. Why these charges exist and why they are constant in magnitude and opposite in sign is one of the great mysteries of nature. It appears that the Continuum must be a dual medium. A permanent vibratory structure evidently cannot exist except around a charge. This charge seems to constitute a radial stretching of one of the parts of the dual medium with a corresponding compression of the other. The supposition is that the Continuum may be distorted only in discrete steps and that each step, or rather the only possible step, corresponds to one charge, dependent in sign on the relative positive or negative displacement of the two assumed constituents. *This concept of the structure of the Universe is an inversion of the conventional one in that the Continuum, normally considered to be empty or ethereal, is here considered to be "solid" in nature, and matter, conventionally thought of as*

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[4] This difference in light velocity is caused by the velocity of the rotation of the Earth with respect to its reference frame, somewhat more than 0.4 kilometers per second. A repetition of the Michelson-Morley experiment for detecting the velocity of translation of the Earth with respect to the ether was carried out by G. Joos about 1930 in the cellar of the Zeiss Works in Jena. This is generally recognized as the most accurate of the many Michelson-Morley type experiments conducted since 1887. "The result obtained is that the velocity of the Earth with respect to the ether, if it exists, cannot be greater than 1.5 km/sec." (*Science Abstracts* (physics) 1931, page 379). This velocity would correspond to a reading of 0.001 of the width of a fringe (Ref.7).

being solid is here considered to be mere vibrations in and of the Continuum.

The strain in the Continuum is due to some sort of pressure and this pressure drops on approaching the stars or planets. *As indicated, the energy, and not the mass of bodies, is the cause of the gravitation and pressure drop. This pressure drop results in a strain system represented by an ellipsoidal strain tensor.* The pressure drop is relatively small, at the Sun in the order of only 10^{-6} of the pressure at infinity in the solar system. But in a medium of an almost infinite modulus of elasticity the actual distortion of the medium is near zero. This is in agreement with the assumption, which may be proved or disproved, that the energy content in a strained Continuum is minuscule.

The author will at this time venture to submit another proposition: Newton's theory of gravitation would result in a gravitation for the total Universe which increased as the radius from the center. To avoid this situation, and the concepts of Einstein, de Sitter, and others, I propose the following: As even the gravitational acceleration of even a large mass like the Sun drops to about 10^{-10} cm/sec^2 at the distance of one light year, and the effect on the Sun from the central portion of the Milky Way is almost of the same negative order of magnitude, it is possible that there exists a lower limit to the effective magnitude of the gravitational force. There is *a priori* no reason why the force should extend to infinity and thus decrease to a mathematical zero. It almost follows from the quantum theory that perhaps a gravitational field in its microstructure might also involve finite steps, and thus cease to act below a certain minimum level and beyond a certain distance.

If this were true, then the Universe would be the same everywhere composed of separate and equal sub-Universes, each independent of the others. I believe that the Universe is finite and bounded, in other words, that there is an outer "edge". This is necessary in order to explain Olbers' Paradox.[5] At this outer edge there is a spherical "shell" comprising a continuous region of black holes into which all the radiation of all the stars is continually fed. In this furnace with probably the most perfect insulation and the consequent enormous temperature the continuous processes of extinction in the visible Universe may be counterbalanced by a continual creation of new elements. From time to time and place to place there may be collapses or explosions and new elements, mainly hydrogen, are forever streaming back into the Universe to form new stars and to fill the "skeletons" of the dead stars. Only by such a process can I explain the Olbers Paradox and the recreation of matter from light. *Only thus may the Universe exist forever.*

Until more facts are known this hypothesis is as valid as any other. For example, the "big bang" theory, supported in the view of its proponents by the theory of the expanding Universe, and by the speculation that the recently discovered diffuse radiation in space is left over from the original "big bang" itself, creates many more puzzles than solutions. The observed phenomenon of the so-called red shift is interpreted as evidence that the Universe is expanding. It may just as validly be explained as being the effect produced by the transfer of momentum from light to electrons in space.

[5] Olber's Paradox states that if no radiation escapes from an enclosure (the universe) then after a certain time the entire space would attain a temperature approaching that of the enclosed radiating bodies.

NOMENCLATURE

c	velocity of light
c_∞	velocity at infinity ($c_\infty = 1$)
c_r	radial velocity
c_t	tangential velocity
v	velocity (also w)
v_r	radial velocity component
v_ϕ	tangential velocity component
r	radius
ϕ	angular coordinate
m	mass (also gravitational mass, $m = Gm_1 / c^2$)
M	Linear momentum
h	angular momentum
p	potential of gravitation
k	integration constant ($k = 2m$)
K	dielectric constant
G	Newton's gravitational constant
V	combined velocity
τ_r	radial stress
τ_ϕ	tangential stress
γ	$1 - 2m / r = 1 - 2mu$
E	energy
E_s	static energy ($E_0 = 1$)
E_v	velocity energy ($E_0 = 1$)
u	$1/r$

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APPENDIX I

Development of Equation 10

One has from Equation 8

$$\left[\frac{1}{c_r^2}\left(\frac{dr}{d\phi}\right)^2+\frac{1}{c_\phi^2}r^2\right]\dot\phi^2=1$$

With

$$u=\frac{1}{r}\,,\ \dot u=\frac{du}{d\phi}\,,\quad \text{one has}$$

$$\left[\frac{1}{c_r^2}\left(\frac{\dot u}{u^2}\right)^2+\frac{1}{c_\phi^2}\left(\frac{1}{u^2}\right)\right]\left(\frac{d\phi}{dt}\right)^2=1\,,\ \text{or}$$

$$F^2\left(\frac{d\phi}{dt}\right)^2=1$$

where $$F^2=\frac{1}{c_r^2}\left(\frac{\dot u^2}{u^4}\right)+\frac{1}{c_\phi^2}\frac{1}{u^2}\,.$$

Thus $$Fd\phi=dt$$

and $$\int Fd\phi=t-t_0$$

The shortest path (in time) is obtained by the Calculus of Variations

$$\frac{\partial F}{\partial u}=\frac{d}{d\phi}\left(\frac{\partial F}{\partial \dot u}\right)$$

We proceed to develop the functions F^2 and F.

$$F^2=\dot u^2A+B$$

$$F\frac{\partial F}{\partial \dot u}=\dot uA \qquad \text{I.}$$

$$2F\frac{\partial F}{\partial u}=\dot u^2\dot A+\dot B \qquad \text{II.}$$

From I

$$F\frac{\partial^2F}{\partial u\partial\dot u}=\dot u\dot A-\frac{\partial F}{\partial u}\cdot\frac{\partial F}{\partial\dot u}=\dot u\dot A-\frac{\partial F}{\partial u}\frac{\dot uA}{F} \qquad \text{III.}$$

From I

$$F\frac{\partial^2F}{\partial\dot u^2}=A-\left(\frac{\partial F}{\partial\dot u}\right)^2=A-\frac{\dot u^2A^2}{F^2} \qquad \text{IV.}$$

From the Calculus of Variations

$$\frac{\partial F}{\partial u}=\frac{d}{d\phi}\frac{\partial F}{\partial\dot u}=\dot u\frac{\partial^2F}{\partial u\partial\dot u}+\ddot u\frac{\partial^2F}{\partial\dot u^2}$$

$$F\frac{\partial F}{\partial u}-\dot uF\frac{\partial^2F}{\partial u\partial\dot u}-\ddot uF\frac{\partial^2F}{\partial\dot u^2}=0 \qquad \text{V.}$$

For the first two terms of Equation V

$$F\frac{\partial F}{\partial u}-\dot u\left[\dot u\dot A-\frac{\partial F}{\partial u}\cdot\frac{\dot uA}{F}\right]$$

$$F\frac{\partial F}{\partial u}-\dot u^2\left[\dot A-\frac{\partial F}{\partial u}\cdot\frac{A}{F}\right]$$

$$F\frac{\partial F}{\partial u}\left(1+\frac{\dot u^2A}{F}\right)-\dot u^2\dot A$$

$$F\frac{\partial F}{\partial u}\frac{F^2+\dot u^2A}{F^2}-\dot u^2\dot A$$

$$\left[F\frac{\partial F}{\partial u}(2\dot u^2A+B)-\dot u^2A(\dot u^2A+B)\right]\frac{1}{F^2}$$

We insert from equation II

$$\left[\left(\frac{1}{2}\dot u^2\dot A+\frac{1}{2}\dot B\right)(2\dot u^2A+B)-\dot u^2A(\dot u^2A+B)\right]\frac{1}{F^2}$$

$$\left[\frac{1}{2}\dot u^2\dot A2\dot u^2A+\frac{1}{2}\dot u^2\dot AB+\frac{1}{2}\dot B2\dot u^2A-\frac{1}{2}\dot BB-\dot u^2\dot A\dot u^2A-\dot u^2\dot AB\right]\frac{1}{F^2}$$

$$\left[\dot u^2\left(A\dot B-\frac{1}{2}\dot AB\right)+\frac{1}{2}B\dot B\right]\frac{1}{F^2}$$

$$\left[\dot u^2\left(\frac{\dot B}{B}-\frac{1}{2}\frac{\dot A}{A}\right)+\frac{1}{2}\frac{\dot B}{A}\right]\frac{AB}{F^2} \qquad \text{VI}$$

For the last term in equation V (without $\ddot u$)

$$F\frac{\partial^2 F}{\partial\dot{u}^2} = A - \frac{\dot{u}^2 A^2}{F^2} = \frac{AF^2 - \dot{u}^2 A^2}{F^2}$$

$$F\frac{\partial^2 F}{\partial\dot{u}^2} = A\frac{(\dot{u}^2 A + B) - \dot{u}^2 A^2}{F^2} = \frac{AB}{F^2} \qquad \text{VII}$$

From equation V

$$\dot{u}^2\left(\frac{\dot{B}}{B} - \frac{1}{2}\frac{\dot{A}}{A}\right) + \frac{1}{2}\frac{\dot{B}}{A} - \ddot{u} = 0$$

$$-\dot{u}^2\frac{d}{du}\ln\frac{B}{\sqrt{A}} - \frac{1}{2}\frac{\dot{B}}{A} + \ddot{u} = 0 \qquad \text{VIII}$$

Insert the coefficients:

$$A = \frac{1}{c_r^2 u^4} \quad B = \frac{1}{c_\phi^2 u^2} \quad \dot{B} = \frac{1}{c_\phi^4 u^4}\frac{d}{du}(c_\phi^2 u^2)$$

Thus equation 10

$$\ddot{u} - \frac{1}{2}\dot{u}^2\frac{d}{du}\ln\left(\frac{c_r}{c_\phi^2}\right)^2 + \frac{1}{2}\left(\frac{c_r}{c_\phi^2}\right)^2\frac{d}{du}(c_\phi^2 u^2) = 0 \qquad \text{IX}$$

APPENDIX II

The Elements of the Stress Tensor in the Continuum

The stress tensor is here represented in ellipsoidal form. The gravitational field of the Sun is of spherical symmetry. The pressure of the field drops as one approaches its center (the Sun). One may write:

$$\pi\frac{d}{dr}\left(\tau_r r^2\right) = 2\pi\tau_\phi r \qquad (1)$$

where r is the radial and ϕ the angular coordinate. τ_r and τ_ϕ are the respective tensor elements.

When $\tau_r = \left(1 - \frac{k}{r}\right)^2$ and $\tau_\phi = 1 - \frac{k}{r}$

and these are inserted into equation (1), the equation is satisfied.

$$\frac{d}{dr}\left[\left(1-\frac{k}{r}\right)^2 r^2\right] = 2r\left(1-\frac{k}{r}\right)$$

$$2(r-k) = 2(r-k)$$

Thus one has the solution that the tensor elements are

$$\tau_r = \left(1-\frac{k}{r}\right)^2 \text{ and } \tau_\phi = 1-\frac{k}{r}$$

where k is an arbitrary constant.