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On a New Mathematical Framework for Fundamental Theoretical Physics

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It is shown by means of general principles and specific examples that, contrary to a long-standing misconception, the modern mathematical physics of compressible fluid dynamics provides a generally consistent and efficient language for describing many seemingly fundamental physical phenomena. It is shown to be appropriate for describing electric and gravitational force fields, the quantized structure of charged elementary particles, the speed of light propagation, relativistic phenomena, the inertia of matter, the expansion of the universe, and the physical nature of time. New avenues and opportunities for fundamental theoretical research are thereby illuminated.

1. INTRODUCTION

The equation $E = mc^2$, which Einstein derived from his special theory of relativity nearly 70 years ago, is regarded today as an expression of a fundamental principle of nature stating that inertia is an intrinsic property of energy. Energy endowed with inertia can thus be visualized today as a fundamental physical aspect of nature, to the extent that we may pick any point in an abstract coordinate space and ask these two questions:

What is the mass–energy density there and what *name*(*s*) shall we give to the *mass–energy* force field(s) that are so defined? Thus, in dealing with force fields of one kind or another we now know that in reality we are dealing with just different manifestations of one fundamental substance in nature called *mass–energy*. On a fundamental level, then, we realize today that the concepts of electricity, magnetism, charge, gravitation, etc., refer only to the various ways in which a mass-energy field manifests itself in our universe. The mass–energy field or simply *the field* is therefore visualized today, by many physicists, as the basic physical feature of our universe, which, as Yilmaz has noted, should have "far reaching consequences in physics."[(1)]

Much interest has therefore been directed toward the problem of developing a set of essentially classical or continuous *mass–energy field laws* that would be useful for unveiling the mysteries surrounding the internal and external structure of all mass–energy field-particles. Hopefully, as these field laws evolve they will help to provide the kind of unprecedented pointwise continuous picture of elementary particle structure and force fields that Einstein stubbornly insisted would one day be possible.[(2)] Such field laws would necessarily be based on a notion maintained by Einstein for the last 35 years of his life. Namely, that "space is endowed with physical properties, without which" he said,

> There not only would be no propagation of light, but also no possibility of existence for standards of space and time (measuring rods and clocks), nor therefore any space–time intervals in the physical sense.[(3)]

It seems only natural to suppose that mass–energy is a latent or potential property of space and that what we seek in a unified field theory are the equations which govern the way in which space (or what we shall here refer to as *space–energy*) evolves in time to account for the empirical mass–energy fields and field-particles observed in our universe.[(4),1] In this regard Dirac has observed that a theory which has or hopes to have the capability to explain charge need not regard the uncertainty principle as being fundamental at the outset. It must only be based on a "new mathematics that happens to work" and, almost certainly, "a drastically different physical picture of the universe."[(5)]

The main purpose of this paper is to suggest through a self-consistent *theory of space–energy* and numerical examples that the modern mathematical physics of *mass–energy* fluid dynamics is perhaps a greatly overlooked mathematics that happens to work. Thus this shows that its primitive utility in providing the mathematical formalisms for all four of Maxwell's equations (nearly 120 years ago) was perhaps not as accidental as it may have seemed.[(6),2]

[1] See also Ref. 1, pp. 180–182.
[2] See also Ref. 11, p. 2.

The advances in the theory of fluid mechanics which make it so appropriate for a space–energy field theory today are due not so much to the fact that it is now expressed with the elegance and economy of the tensor and vector calculus, although that itself has been extremely eventful, but rather the fact that it has grown into a much more general theory by virtue of the fact that it now deals effectively with the *compressible* or generally *nonlinear* characteristics of a macroscopic mass–energy continuum. The word "continuum" is here used loosely, as a statistically meaningful way of visualizing the group-theoretic properties of a loosely bound collection of mass-energy field-particles. Yet the message still seems quite clear. The fluid dynamic laws of such a continuum must be entirely consistent with the fundamental field laws governing the mass–energy fields that make up that continuum.[7] Consequently, it is only logical to suppose that space–energy itself can be visualized and described mathematically as an *idealized*, compressible fluid dynamic *reference* or *zero-point* continuum, representing mass–energy in its most fundamental form. Such are the conclusions that can be drawn today because of the many technological and conceptual advances that have been made possible because of Einstein's great intellectual accomplishments during the early part of this century.

In Section 2 of this paper, we show that the theoretical structure and consequences of Einstein's special theory of relativity can be richly exploited to develop an equivalent theory of space–energy which, by taking $E = mc^2$ as its only basic assumption, reproduces the empirical consequences of special *and* general relativity in a way that immediately illustrates the logical necessity and practical value of regarding space–energy as a unifying fluid dynamic construct. In Section 3 we then show that Einstein's acceleration equivalence principle and a few of the empirical consequences of his general theory of relativity, relating to the gravitational red-shift and the development of black holes, are conveniently derivable from a single vector equation defining the acceleration of space–energy.

In Section 4, we provide an illustrative fluid dynamic analysis of charge quantization, as a fundamental consequence of the compressibility or nonlinear characteristics of the space–energy field. The analysis yields a realistic electron "size" and a totally fluid dynamic formulation of the speed of light and the fine structure constant. The analysis also yields a unit conversion constant which serves to transform all "electromagnetic" units into the units of only mass, length, and time, thereby illuminating the fluid-thermodynamic significance of the "electromagnetic" fields and constants of nature. It is thus shown that the zero-point mass–energy density of space–energy is comparable to the *differential* or *empirical* mass–energy density of nuclear matter. In Section 5, we develop a fluid dynamic hypershock model of the expanding universe, along the lines originally proposed by Wheeler.

We qualitatively discuss the ways in which such a model could account for the origin of all force fields, the symmetry breakdowns observed in high energy particle physics, and the universal ordering and change parameter called *time*. In a future paper it will be shown that blurred point sources representing nth-order image poles of the radiation from galaxies should occur throughout such a universe, producing radiation intensities, red-shifts, and emission and absorption spectra characteristic of quasistellar objects.

In summary, the primary objective of this article is to alert theoretical physicists to the fact that the branch of mathematical physics dealing with the fluid laws of mass–energy provides a very appropriate and efficient language for studying basic physical phenomena. At the present time, it appears that the major difficulty confronting a significant advance in our understanding of matter, space, and time lies in the enormous challenge of extending fluid mathematics to include motions of space–energy in four or more dimensions of abstract coordinate space. If the *time* force field (described in Section 5) does indeed exist throughout the entire universe, one can readily anticipate that such research will lead to previously unimagined methods of energy conversion, propulsion, and communication.

2. ON THE AXIOMATIC FOUNDATIONS OF SPACE–ENERGY

The power equation of classical (19th century) mechanics, $dE/dt = \mathbf{F} \cdot \mathbf{v}$, expresses the rate at which energy E is given to a body of mass m through a force $\mathbf{F}$ at the moment t that the body is moving with velocity $\mathbf{v} = \boldsymbol{\beta} c$ relative to the coordinate system of an inertial observer. There is perhaps no other equation in physics which interrelates so many seemingly fundamental physical quantities. This is especially clear when we introduce the mass explicitly through Newton's force equation $\mathbf{F} = d\mathbf{P}/dt$, where $\mathbf{P} = m\mathbf{v}$ is a fundamental quantity in Nature called momentum. If we now introduce the fact that E and m are fundamentally interrelated through the independent equation $E = mc^2$, we immediately obtain the pair of differential equations $dE/E = dm/m = d(\frac{1}{2}\beta^2)/(1 - \beta^2)$ and their solutions

$$E/E_0 = m/m_0 = \gamma \tag{1}$$

where γ defines the well-known velocity factor $1/(1 - \beta^2)^{1/2}$. Thus, with 70 years of hindsight, we see that the well-known variation of mass–energy with velocity can be viewed, most simply, as a natural physical characteristic of mass–energy itself, or rather, the space–energy field laws which govern the organization, structure, and dynamic characteristics of space–energy force fields. It can be shown that Eq. (1), together with the conservation laws for linear and angular momentum and the electromagnetic equation

$$c = 1/(\epsilon_0 \mu_0)^{1/2} \tag{2}$$

for the speed of light propagation, are entirely sufficient to derive the remaining empirical consequences of Einstein's special theory of relativity, and also a space–energy theorem called the absolute principle of relativity (APR), which states that:

> The laws of nature are invariant with respect to an observer's constant velocity through a single physical space–energy continuum of the universe.[8]

It follows from the APR that, despite their various states of uniform motion through space–energy, every inertial observer will find that he or she is completely empirically justified in asserting that he or she is at rest in the space–energy continuum of the universe. Such observers are therefore endowed with all of the theoretical and philosophical attributes that go along with having an absolute viewpoint of all motion and hence the laws governing the operation of the physical space–energy universe in which they live. That the APR can be derived from Eqs. (1) and (2), as stated above, is most clearly demonstrated by reviewing a converse sequence of deductions which run parallel to those that evolved in the special theory of relativity and which are therefore easier to follow. Thus, we will attempt to show that the APR, regarded as a postulate, together with Eq. (2) and the classical momentum conservation laws are entirely sufficient to derive the empirical consequences of special relativity, and to show that all observable physical phenomena can be attributed directly to space–energy field laws which are formulated in accordance with the requirements of the APR. The invariance of physical laws, in the context of the APR, is here regarded in the widest possible sense, so that it includes, along with the form invariance of physical laws, the invariance of any related proportionality constants, assuming of course that the same physical standards and system of units are employed by each of two observers. As absolute observers we can readily envision that magnetic fields originate through the absolute acceleration of charge through space–energy, that electric fields are likewise some manifestation of space–energy, and that the electromagnetic constants, which serve to fix the absolute speed of light propagation through space–energy, are evidently related to the reference fluid-thermodynamic properties of space-energy. In any event it is clear that the velocity of light propagating in a given direction $\boldsymbol{\eta}$ of space–energy can be expressed vectorially as $\mathbf{c} = c\boldsymbol{\eta}$, and the velocity of light relative to a point moving with velocity $\mathbf{v} = \boldsymbol{\beta} c$ through space–energy is therefore expressed either by the vector equation $\mathbf{w} = \mathbf{c} - \mathbf{v}$, or by the scalar phase velocity equation[9]

$$c' \equiv \mathbf{w} \cdot \boldsymbol{\eta} = c(1 - \boldsymbol{\beta} \cdot \boldsymbol{\eta}) \tag{3}$$

This equation has a unique theoretical significance and importance only in a space–energy universe. In accordance with the APR, Eqs. (2) and (3) must be invariant with respect to an observers velocity through space–energy. Such equations may be conveniently referred to as *velocity invariant* equations, or equations which satisfy the principle of *velocity invariance*. The empirical consequences necessitated by the velocity invariance of Eqs. (2) and (3) can be readily deduced by first requiring that the period of a moving light-clock be independent of its orientation relative to its velocity $\mathbf{v} = \boldsymbol{\beta} c$ through space–energy. The period of such a clock at rest in space–energy is clearly given by the time interval $T_0 = 2L^0/c$ required for the to and fro propagation of light between two mirrors separated by a distance labeled as L^0. When the clock is set in motion the anisotropy described by Eq. (3) generates values of $T_\parallel = 2\gamma^2 L_\parallel/c$ or $T_\perp = 2\gamma L_\perp/c$ for the light-clock period corresponding to a parallel or perpendicular orientation of its cavity relative to $\mathbf{v}$. From the requirements that $T_\parallel = T_\perp$ and $L_\perp = L^0$,[10],[3] it follows that the physical geometry of matter must be affected by its absolute velocity through space–energy in accordance with the equations

$$L_\parallel = L_\parallel{}^0/\gamma, \qquad L_\perp = L_\perp{}^0 \tag{4}$$

These equations may thus be regarded as necessary only to ensure that the period of time defined by a moving light-clock will be independent of its orientation in space–energy. The resulting period, however, is observed to be γ times greater than its rest period T_0. Consequently, it follows that the velocity invariance of Eq. (2) can only be assured if the periods of all other moving clocks are also *caused* to increase by the same factor. Thus, the velocity invariance of Eqs. (2) and (3) requires that the periods of all clocks must be affected by their velocity through space–energy in accordance with the equation

$$T = \gamma T_0 \tag{5}$$

The way in which Eqs. (2)–(5) are related to Eq. (1) and hence the field laws of space–energy in general is described as follows. It is well known that the increase of mass with velocity, in accordance with Eq. (1), can be derived on the basis that it must occur if the classical momentum conservation (CMC) laws are still valid in a universe where velocity determinations

[3] See also Ref. 11, pp. 288, 289.

are generally made with rods and clocks whose structures and periods are governed by Eqs. (4) and (5).[11] This is particularly well illustrated by a thought experiment involving an elastic collision between two particles (Ref. 11, pp. 318, 319), and/or by the following thought experiment involving a so-called disk-clock, defining a period $T_0 = 2\pi/\omega_0$ of a freely spinning disk. The angular momentum **L** of the disk is clearly proportional to $m_0\boldsymbol{\omega}_0$, where m_0 is the rest mass of the spinning disk. It follows that **L** will be conserved if we give the disk-clock a translational velocity $\mathbf{v} = \boldsymbol{\beta}c$ parallel to $\boldsymbol{\omega}_0$ by means of a collinear impulse **J**. In accordance with the relativistic notion, that Eq. (5) expresses a time dilation, the spin rate of the disk-clock must decrease to the value $\omega = \omega_0/\gamma$. Consequently in a space–time universe the mass and hence moment of inertia of the disk must "appear" to increase by the factor $m/m_0 = \gamma$. It necessarily follows that Eqs. (1)–(5) describe five physical phenomena which, in view of the CMC laws, are seen to be mathematically and physically interdependent. It then follows that at least one of these equations is totally dependent on all the rest, and thus, however useful it may be, that equation can be regarded as being fundamentally superfluous, in the sense that the phenomenon it describes can always be explained in terms of the phenomena described by the remaining equations.

In keeping with our basic assumption that $E = mc^2$ expresses a fundamental principle of nature, we are led, by the above examples concerning the periods of light-clocks and disk-clocks, to the conclusion that Eq. (5) is a valid and independently useful but, nevertheless, superfluous equation of physics. This conclusion underlies a clock principle (CP) corollary of the APR, which states that:

> The period of any cyclic physical process or clock having an absolute velocity $\mathbf{v} = \boldsymbol{\beta}c$ relative to space–energy is $1/(1 - \beta^2)^{1/2}$ times greater than its rest period due to velocity-dependent changes that have occurred in the pertinent physical phenomena and/or space–energy field laws which account for the rest period of the clock.

Thus, in the disk-clock example above, it can be argued that the decrease in its spin rate by the factor $1/\gamma$ is a direct consequence of its mass increase by the factor γ, such increase being supplied, via an energy-conserving cause–effect budget, from the agency initiating the impulse **J**. In the light-clock example above, it can be argued that the decrease in the physical dimensions of objects expressed by Eq. (4) and hence the clock frequency by the factor $1/\gamma$ is a direct consequence of the way in which space–energy fields naturally transform under absolute accelerations of space–energy field-particles. An illustrative case in point concerns the "electromagnetic" subset of space–

energy field laws, which, although insufficient to account for their own origins (plus and minus charges), or field-particle structure in general, or gravitation, do satisfy the APR and do account naturally for an increase of the "electromagnetic" mass–energy with velocity and the corresponding contraction of atomic matter with velocity in accordance with Eqs. (1) and (4). Our present understanding of this latter fact is due in a large way to the outstanding theoretical contributions and accomplishments of Lorentz at the turn of this century in the areas of theoretical and applied electrodynamics.[12–14] The preceding considerations therefore give support to the general thesis offered at the beginning; that all velocity-invariant space–energy field laws are constrained to yield field-particles which exhibit the extensive behavior laws governed by Eqs. (1)–(5), and/or the laws of mechanics in general, such laws being consistent with the assumption that $E = mc^2$ expresses a fundamental principle of nature.

2.1. On a New Physical Phenomenon

The foregoing considerations illuminate a new physical phenomenon in the universe and an analytic method for dealing with it, which together form an efficient mathematical and physical basis for approaching the development of a unified theory of force fields, and hence of the universe at large. The mere fact that Eq. (3) emerges in the theoretical framework of a space–energy universe invites the prediction that:

> An anisotropy, motion, or flow of space–energy generally exists throughout the universe, and its presence is generally observable through a variety of force fields associated with its various modes of accelerated motion.

It also follows from the foregoing considerations that the formulation of velocity-invariant fluid dynamic space–energy field laws can be guided and facilitated by the following mathematical principles: (i) Time advances at the same "rate" throughout the entire universe. (ii) The concept or abstraction of empty space is nothing more, and nothing less, than an indispensable visualization which the mind conveniently develops as a mathematical aid for describing the generally continuous distributions of space–energy and the laws governing its extensive and intensive properties. Neither (i) nor (ii) need be imagined to be influenced in any way by physical processes and/or force fields. (iii) The number of useful equations in physics is increased by one; namely, Eq. (3), and the number of superfluous equations in physics is, consequently, also increased by one; namely, Eq. (5). (iv) The vector addition theorem of the vector calculus applies equally and without restriction to the vector quantities describing the motion and physics of matter and radiation. (v) In truth, all empirical measurements have only a *relative* theoretical significance. In practice, all empirical observations have an *absolute* theoretical and philosophical significance. (vi) Every empirically significant, velocity-invariant formula, law, and constant of nature in physics can be visualized from the viewpoint of an absolute observer and assumed to reveal something of absolute theoretical significance regarding the field laws of space–energy.

Many of the above principles are illustrated in one way or another by the following solution to a well-known problem. An oscillator having a frequency ν_0 when at rest relative to a space–energy frame is accelerated to a velocity $\mathbf{v} = \boldsymbol{\beta}c$. What is the frequency ν of the radiation propagating in the direction $\boldsymbol{\eta}$ of space–energy? In accordance with the CP corollary the actual frequency of the oscillator ν' can be nothing other than $\nu' = \nu_0/\gamma$. But physical reasoning dictates that the frequency actually radiated throughout space-energy will vary in accordance with the classical Doppler effect governed by Eq. (3), so that $\lambda = \lambda'(1 - \boldsymbol{\beta} \cdot \boldsymbol{\eta})$. Thus $\nu = \nu_0/[\gamma(1 - \boldsymbol{\beta} \cdot \boldsymbol{\eta})]$ constitutes the general velocity-invariant solution to the problem given (see Ref. 9, p. 62). Many interesting theoretical and physical insights can be expected to follow from an absolute interpretation of existing physical laws, and especially from efforts to verify the validity of the CP corollary for more complicated types of cyclic physical processes than those considered here.

3. ON THE SPACE–ENERGY PHYSICS OF GRAVITATION

From his considerations of the mathematical similarity between inertial and gravitational forces, Einstein developed his now famous acceleration equivalence principle (AEP) which expressed his belief in the local equality of inertially accelerated and stationary gravitational frames of reference. From the viewpoint of an absolute space–energy observer, Einstein's AEP asserts that there is an exact physical equivalence, in the neighborhood of a point, between the case (a) where a force is applied to accelerate a particle relative to the free-space continuum of space–energy, and the case (b) where a force is applied to prevent a particle from accelerating under an equal gravitational force.[15] It follows that with respect to an accelerating reference frame there is an exact physical equivalence between the gravitational force per unit mass and the inertial reaction force per unit mass which opposes the absolute acceleration of matter relative to the field-free continuum of space–energy. In the latter case, the inertial reaction force may be attributed directly to a spatially uniform acceleration $\mathbf{a}_{IR} = \partial\mathbf{q}/\partial t = -\partial\mathbf{v}/\partial t$ of the field-free continuum of space–energy, where $\mathbf{q}$ and $\mathbf{v}$ denote the symmetric absolute velocities of space–energy relative to matter and of matter relative to space–energy. It follows that the acceleration field of gravity $\mathbf{a}_g$ can be generally represented (in three dimensions) by the fluid dynamic acceleration vector $\mathbf{a}_g = d\mathbf{q}/dt = \partial\mathbf{q}/\partial t + \mathbf{q} \cdot \nabla(\mathbf{q})$, which is conveniently reexpressed through well-known vector identities in the form

$$\mathbf{a}_g = \partial\mathbf{q}/\partial t + \nabla(\tfrac{1}{2}q^2) - \mathbf{q} \times \boldsymbol{\zeta} \tag{6}$$

Here $\boldsymbol{\zeta} = \nabla \times \mathbf{q}$ defines the circulation density or vorticity of space–energy.[16,17] Equation (6) shows that three-dimensional accelerations of space–energy can arise from explicit velocity changes with time, and/or spatial variations of the flow field, and/or from circulating flow fields. It follows that a centrally symmetric and "static" Newtonian gravitational field is represented through the AEP identity $\nabla(-\phi) = \nabla(\frac{1}{2}q^2)$ as a steady $(\partial\mathbf{q}/\partial t) = 0)$ and irrotational $(\boldsymbol{\zeta} = 0)$ acceleration flow field of space–energy. This AEP identity serves to identify the Newtonian gravitational potential energy per unit mass $(\phi(r) = -GM/r)$ as a quadratic function of the velocity of space–energy

$$\phi(r) = -\tfrac{1}{2}q^2(r) \tag{7}$$

From this we see that a field-free or free-space region of space–energy is defined by the condition $\phi = q = 0$. It is only in such a region that the zero-point or reference properties of space–energy serve to account fully for the ordinary inertia of matter typically identified with the vacuum of free space. From the viewpoint of absolute observers at rest in a field-free region of space–energy, we can visualize the effects of gravitation on matter and radiation in terms of the effects stemming from the absolute field velocity $\mathbf{q}(r)$ relative to stationary field points $\mathbf{r}$ where matter and/or radiation are present. If we restrict our observations to the vicinity of field points, it can be safely assumed that $\mathbf{q}(r)$ represents the average velocity of space–energy throughout a given test body. The procedure of applying a force to insert and maintain a test body at a position $\mathbf{r}$ of the field, where the velocity of space–energy is $\mathbf{q}(r)$, is therefore physically equivalent to the procedure of applying a force to accelerate a test body to a velocity $\mathbf{v} = \boldsymbol{\beta}c$ relative to free space. Thus, in both cases the work done on the test body can be regarded as the cause underlying the generation of an absolute space–energy anisotropy in the frame of the test body. It follows that the nonlinear properties of mass–energy, previously described by the *particle velocity* function $\gamma = 1/(1 - \beta^2)^{1/2}$ in Section 2, will be exhibited by stationary test bodies in the gravitational field in accordance with the symmetric *field velocity* function

$$Y(r) \equiv 1/[1 - u^2(r)]^{1/2} = 1/[1 + 2\phi(r)/c^2]^{1/2} \tag{8}$$

where $\mathbf{u}(r) \equiv \mathbf{q}(r)/c$. The second expression for $Y(r)$ is seen to follow trivially from Eq. (7). Thus, in accordance with the physics described by Eqs. (1)–(5), the speed of light and the (M, L, t) measurement standards at points in the field of gravity are governed by the equations

$$c' = c(1 + \mathbf{u} \cdot \boldsymbol{\eta}) \tag{9}$$

$$m(r) = Y m_0 \tag{10}$$

$$\begin{aligned} L_\parallel(r) &= L_\parallel{}^0/Y \\ L_\perp(r) &= L_\perp{}^0 \end{aligned} \tag{11}$$

$$T(r) = Y T_0 \tag{12}$$

For basically the same reasons given in Section 2, it follows that a local observer at rest in the field of gravity will find that he is empirically justified in assuming that space–energy is isotropic and that his measurement standards are absolute. However, in accordance with the CP corollary, and hence Eq. (12), the general slowing down of physical processes in a gravitational field will cause an observer located at $r = r^*$ to find that radiation from sources located above and below him will be blue-shifted and red-shifted, respectively, in accordance with the equations

$$\nu(r^*) = \nu_0 Y(r^*)/Y(r) \tag{13}$$

$$\nu(r^*) - \nu(r) \simeq 0.5\nu_0[u^2(r^*) - u^2(r)] \tag{14}$$

$$\simeq \nu_0[\phi(r) - \phi(r^*)]/c^2 \tag{15}$$

The same formulas apply of course even if the radiation source is located in the gravitational field of another body, in which case the radiation "from above" could easily exhibit a net red-shift. It can be shown that the Doppler shift at the source of the radiation required by Eq. (9) is always cancelled out in the measurement process due to the fact that the ratio of the speed of propagation to the wavelength $c'(\mathbf{u} \cdot \boldsymbol{\eta})/\lambda'(\mathbf{u} \cdot \boldsymbol{\eta})$ is preserved throughout the flow field. The absolute frequency of radiation $\nu(r) = \nu_0/Y(r)$ emitted at a given point r in the gravitational field therefore remains constant. It is only the relative rate of the observer's clock that determines whether or not the frequency of radiation he observes will be larger or smaller than ν_0. With the exception of Eq. (9), Eqs. (8)–(15) and the results discussed above agree exactly with the empirical consequences previously deduced from Einstein's general theory of relativity, where the function $Y(\phi/c^2)$ shown in Eq. (8) describes the "metrical" coefficients $-g_{44} = 1/Y^2$ and $g_{11} = Y^2$.[4]

[4] See Ref. 9, pp. 247, 248, and 291; Ref. 12, pp. 160–164 of Dover edition; Ref. 18, pp. 323–327.

3.1. On the Development and Exploitation of a Space–Energy Velocity-Metric $W_{ik}(u)$

The foregoing considerations suggest a novel theoretical procedure for exploiting Einstein's field equations to obtain theoretical insights into the formal structure of a unified theory of force fields. The procedure is based on the identification of a *velocity-metric* tensor $w_{ik}(u)$ which is mathematically equivalent to the general relativistic space–time metric tensor g_{ik} in the sense that it ensures the local velocity invariance of the interval ds define by

$$ds^2 = w_{ik}(u)\, dx^i\, dx^k \tag{16}$$

The $w_{ik}(u)$ tensor, however, contains explicit functions for a generalized matter and/or space–energy velocity $\mathbf{w} = \mathbf{u} - \boldsymbol{\beta}$ which represents the *net* absolute velocity $\mathbf{w} = (\mathbf{q} - \mathbf{v})/c$ of space–energy relative to matter. For stationary field points, $\boldsymbol{\beta} = 0$ and $\mathbf{w} = \mathbf{u}$ represents the generalized space–energy velocity of the field $\mathbf{F}$ associated with a given source. The *fluid* field laws associated with that source can then be deduced (hopefully to a large degree) by inserting the appropriate energy–momentum tensor $T_{ik}(\mathbf{F})$ into Einstein's general relativistic equation

$$R_{ik} = (8\pi G/c^2)[T_{ik}(\mathbf{F}) - \tfrac{1}{2} w_{ik}(u)\, T(\mathbf{F})] \tag{17}$$

and obtaining the resulting partial differential equations for the $w_{ik}(u)$ and hence the fluid field equations $\mathbf{F}(u)$ for that source. The derivation of the w_{ik} is facilitated by realizing that they are quantities which transform the absolute mathematical descriptions of rods and clocks into the local observer's empirical definitions of space and time intervals. Both descriptions employ the same arbitrary labels for the physical length L_0 of an object and the time interval T_0 represented by one cycle of a cyclic physical process or clock. We know, however, from our absolute viewpoint, that the actual length L of a rod is generally less than L_0 and that the actual period T of a clock is generally greater than T_0. Consequently we know that the coefficients $w_{\alpha\beta}$ (for $\alpha, \beta = 1, 2, 3$) must describe the amount by which a local observer *overestimates* the extension of space, and the coefficient w_{44} must determine the amount by which he *underestimates* the rate at which time advances. We derive the $w_{\alpha\beta}$ then by considering a rod whose actual length and direction, as viewed from our abstract coordinate space, is $d\mathbf{r}(r)$ at a point $\mathbf{r}$ where the velocity of space–energy is defined as $\mathbf{q} = c\mathbf{u}$. We then resolve $d\mathbf{r}$ into components $d\mathbf{r}_\parallel$ and $d\mathbf{r}_\perp$ which are parallel and perpendicular to $\mathbf{q}$. From Eq. (11) we know that an observer at the point $\mathbf{r}$ will be empirically justified in asserting that the rod defines a larger spatial interval $d\mathbf{r}' = \Upsilon\, d\mathbf{r}_\parallel + d\mathbf{r}_\perp$. The locally *defined* spatial interval $(dr')^2$ is therefore related to the absolute spatial interval at $\mathbf{r}$ by the equation $(dr')^2 = Y^2(d\mathbf{r} \cdot \mathbf{u})^2 + dr^2 = w_{\alpha\beta}\, dx^\alpha\, dx^\beta$. This serves to identify 9 of the 16 $w_{ik}(u)$ through the tensor

$$w_{\beta\alpha} = w_{\alpha\beta}(u) = \delta_{\alpha\beta} + Y^2(u) u_\alpha u_\beta \tag{18}$$

where $\delta_{\alpha\beta} = 1$ for $\alpha = \beta$, or 0 for $\alpha \neq \beta$. In order to preserve the indefinite signature of the tensor $w_{ik}(u)$, it is necessary to multiply either w_{44} or all of the $w_{\alpha\alpha}$ coefficients by (-1). Arbitrarily applying this operation to w_{44} and using Eq. (12), we obtain $w_{44} = -1/Y^2$. Since these are the only transformations necessary to ensure the invariance of ds for local observers, we conclude that the $w_{4\alpha}$ and $w_{\alpha 4}$ terms of $w_{ik}(u)$ are identically zero. We therefore obtain the complete velocity-metric interval in the explicit form

$$\begin{aligned} ds^2 &= w_{ik}(u)\, dx^i\, dx^k \\ &= \{\delta_{\alpha\beta} + [u_\alpha u_\beta/(1 - u^2)]\}\, dx^\alpha\, dx^\beta - (1 - u^2) c^2\, dt^2 \end{aligned} \tag{19}$$

The indefinite signature of the tensor $w_{ik}(u)$ is ensured by noting that its determinent $(w_{44} \mid w_{\alpha\beta} \mid)$ is equal to -1. If $\mathbf{u} = u(r)\hat{\mathbf{r}}$, then in a spherical coordinate space for which $dx^\alpha = (dr, r\, d\theta, r \sin\theta\, d\phi)$, the interval takes the form

$$ds^2 = [dr^2/(1 - u^2)] + r^2(\sin^2\theta\, d\phi^2 + d\theta^2) - (1 - u^2) c^2\, dt^2 \tag{20}$$

Equation (20) is the velocity-metric interval for any purely radial field. Consequently, using Eq. (8) to relate $u(r)$ to $\phi(r)$ generates precisely the same metric that results from Einstein's field equations for the case of a centrally symmetric gravitational field. In this regard we note that the coefficients $w_{44} = -1/w_{11} = -(1 + 2\phi/c^2)$ together with the Hamilton-Jacobi equation of mechanics (and radiation) lead directly to the general relativistic results for the perihelion precession of elliptical orbits and the bending of light in the gravitational field (see Ref. 18, pp. 334–338). One can therefore hope that the use of the $w_{ik}(u)$ tensor as the dependent field variable in Einstein's field equations will help to generate valuable insights for the formal structure of a unified theory of force fields. Progress in this direction would vindicate yet another of Einstein's intuitive convictions; that "the final correct solution must start with general relativity."[19]

We note in passing that the development of a black hole is here identified with the condition $q \to c$. This naturally suggests that the phenomenon be viewed as a macroscopic shock singularity in space–energy. Likewise, the general relativistic results showing that the radius R of the expanding universe can be viewed as that of a cosmological black hole or Schwarzschild singularity suggest that this phenomenon might also be consistently viewed as a shock phenomenon in space–energy. This is precisely the kind of phenomenon that highlights the theoretical nonlinear continuum physics of compressible fluid dynamics, and in the next two sections we will attempt to illustrate the fundamental role that nature seems to have assigned to this particularly interesting characteristic of space–energy.

4. ON THE SPACE–ENERGY PHYSICS OF CHARGE

Using MKS units throughout and a subscript s to distinguish space–energy quantities from ordinary thermodynamic and electromagnetic quantities, we investigate the theoretical consequences of regarding a space–energy momentum density flux vector $\mathbf{D}_s \equiv \rho_s \mathbf{q}$ as the physical quantity presently represented by the electric displacement vector $\mathbf{D} \equiv \epsilon \mathbf{E}$. It is shown that unlike $\mathbf{D}$, $\mathbf{D}_s$ has an intrinsic maximum value that it can attain $\mathbf{D}_s{}^*$, which serves to define an empirical electron radius $r_* = 1.56 \times 10^{-15}$ m and a space–energy mass-flux $e_s = (2/137.04)\,\hbar/r_*{}^2$. A unit conversion constant $\chi \equiv e/2\pi r_*{}^2$ is then derived and shown to be generally useful for transforming electromagnetically defined quantities into space–energy quantities. The constants $1/\epsilon_0$ and μ_0 are thus transformed into the zero-point energy and mass densities of free space. A *point source* field velocity of 2.5×10^{-13} m/sec is then shown to be the equivalent of 1 V/m in the far-field region ($r > 3r_*$) of an elementary charged particle.

The equations and basic assumptions employed in the analysis are described as follows. We assume that field-free space is characterized by a zero-point space–energy density $\psi_0 \equiv \rho_{s0} c^2$ and a pressure $p_{s0} = \psi_0/3$. The variations of $p_s(q)$ and $\rho_s(q)$ are then assumed to be *dynamically* interrelated through Euler's equations of motion for an irrotational field $[\rho_s\, d(\frac{1}{2}q^2) = -dp_s]$, while also being *fundamentally* interrelated through a space–energy equation of state $p_s = k\rho_s{}^3$. The speed of propagation of pressure and density perturbations, which we here assume to be that of light, is then governed by the standard equation $(c')^2 = dp_s/d\rho_s$. Using the above equation of state, we obtain $(c')^2 = 3p_s/\rho_s$ in the presence of fields, and $c^2 \equiv \psi_0/\rho_{s0} = 3p_{s0}/\rho_{s0}$ in free space. Finally, we assume that the empirical electrostatic mass–energy density ϵ_{em} at a point in the field is equal to the difference between ψ_0 and the actual energy density $\psi = \rho_s c^2$ at that point. Defining $\mathbf{u} = \mathbf{q}/c$ and $\Upsilon = 1/(1 - u^2)^{1/2}$ as before, we find that Υ serves to decouple all of the above relationships and definitions, thus yielding the equations

$$\psi/\psi_0 = c'/c = 1/\Upsilon \tag{21}$$

$$p_s/p_{s0} = 1/\Upsilon^3 \tag{22}$$

$$\epsilon_{em} \equiv \psi_0 - \psi = \psi_0(1 - 1/\Upsilon) \tag{23}$$

$$\mathbf{D}_s \equiv \rho_s \mathbf{q} = \rho_{s0} c\mathbf{u}/\Upsilon \tag{24}$$

Differentiating Eq. (24) with respect to u shows that the magnitude of $\mathbf{D}_s$ can never exceed the value $D_s{}^* = \rho_{s0}c/2$, for which $q = 0.707c$ is also equal to the local speed of light c'. The shock wave physics underlying this physical limitation or quantization of $\mathbf{D}_s$ is described in Section 5. For the present, it is sufficient to realize that the conservation of space–energy mass, within the confines of our three-dimensional space, requires continuity of the mass-flux $e_s = \iint \mathbf{D}_s \cdot \mathbf{n}\, dS$ through any and all surfaces S enclosing a source (or sink) of $\mathbf{D}_s$. The analysis which follows will show that we are justified in assuming that the maximum value of $\mathbf{D}_s$ is equal to $\mathbf{D}_s{}^*$, and that the radius r_* at which this occurs describes an empirically meaningful radius for an electron. Using r_* and $D_s{}^* = \rho_{s0}c/2$ in the equation of continuity, we find that the phenomenon of charge interrelates four seemingly fundamental constants of space–energy through the equation $2\pi = e_s/(\rho_{s0}cr_*{}^2)$. For reasons which will become readily apparent, we define this relationship as a course structure or CS constant. The connecting link between the CS constant and the fine structure (FS) constant is obtained by determining the radial variation of $\epsilon_{\rm em}(r)$ for $r \geqslant r_*$. Defining $\lambda \equiv r_*/r$ and the function $H(\lambda) \equiv [1 + (1 - \lambda^4)^{1/2}]^{1/2}/\sqrt{2}$, we find that $u(\lambda) \equiv q(\lambda)/c = \lambda^2/2H(\lambda)$. Using $u(\lambda)$ in Eq. (23), we obtain $\epsilon_{\rm em}(\lambda)$ in the form

$$\epsilon_{\rm em}(\lambda) = \psi_0[1 - H(\lambda)] \tag{25}$$

$$= \psi_0\lambda^4/8 \qquad (\text{for } \lambda^4 << 1.0) \tag{26}$$

$$= e_s{}^2/(32\pi^2\rho_{s0}r^4) \tag{27}$$

The variation of $\epsilon_{\rm em}$ with $\lambda^{-1} = r/r_*$ is shown in Fig. 1 along with the other quantities of interest, like $\psi/\psi_0 = c'/c = H(\lambda)$ and $p_s/p_{s0} = H(\lambda)^3$. Evidently a linear or incompressible analysis of charge would begin to fail at a distance of about $3r_*$. From the form of $H(\lambda)$ we see that the far-field or linear region (where $c'/c = \psi/\psi_0 = p_s/p_{s0} \simeq 1.0$) is determined by the criterion $\lambda^4 << 1.0$. The far-field mass–energy density expressed by Eq. (27) follows by using the CS constant to eliminate r_* in Eq. (26). Comparing Eq. (27) with the electromagnetic expression $\epsilon_{\rm em} = e^2/(32\pi^2\epsilon_0 r^4)$, we deduce an identity between the ratio of two space–energy constants and the ratio of two electromagnetically defined constants,

$$e_s{}^2/\rho_{s0} \equiv e^2/\epsilon_0 \tag{28}$$

This identity and the CS constant provide all the information needed to transform all electromagnetically defined fields, concepts, and constants into space–energy fields, concepts, and constants of nature. Some of these transformations and other related equations are listed below and then discussed.

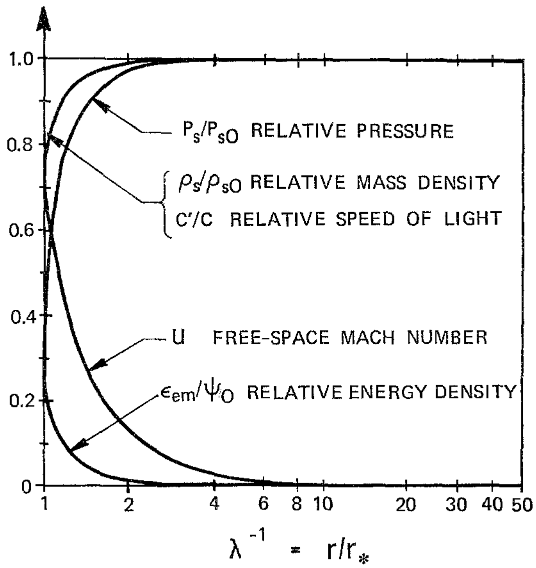

Fig. 1. The radial variation of space–energy quantities defining the field of an elementary charged particle with a shock-limited radius equal to r_* .

$e_s = 2\alpha\hbar/r_*^2$	$[6.3 \times 10^{-7}$ kg/sec]	(29)
$\hbar = 137.04\pi\rho_{s0}\, c r_*^4$	$[6.626 \times 10^{-34}$ J-sec]	(30)
$c = (\psi_0/\rho_{s0})^{1/2}$	$[2.998 \times 10^8$ m/sec]	(31)
$\chi \equiv e/2\pi r_*^2$	$[1.05 \times 10^5$ C/m^2]	(32)
$\psi_0 \equiv \rho_{s0}c^2 = \chi^2/\epsilon_0$	$[4.14 \times 10^{30}$ J/m^3]	(33)
$\rho_{s0} \equiv \psi_0/c^2 = \mu_0\chi^2$	$[1.38 \times 10^{14}$ kg/m^3]	(34)
$\Gamma \equiv \chi R_0 = \mu_0\, ec/2\pi r_*^2$	$[3.96 \times 10^{12}$ (V/m)/(m/sec)]	(35)
$e_s = \Gamma e$	$[6.3 \times 10^{-7}$ kg/sec]	(36)
$\mathbf{q} = \mathbf{E}/\Gamma$	[m/sec]	(37)
$\mathbf{D}_s = \Gamma\mathbf{D}$	[kg/m^2-sec]	(38)
$e_s\mathbf{q} = \mathbf{F}(\text{far-field}) = e\mathbf{E}$	[N]	(39)
$\mathbf{q}\cdot\mathbf{D}_s = 2\epsilon_{\text{em}}(\text{F-F}) = \mathbf{E}\cdot\mathbf{D}$	[J/m^3]	(40)
$r_e \equiv \mu_0 e^2/4\pi m_e$	$[2.818 \times 10^{-15}$ m]	(41)
$r_* = (4/3)(\sqrt{2} - 1)r_e$	$[1.56 \times 10^{-15}$ m]	(42)

Equation (29) results from using Eq. (28) to eliminate e^2/ϵ_0 in the FS constant $[e^2/(4\pi\epsilon_0\, c\hbar) \equiv \alpha]$ and by then using the CS constant to eliminate $\rho_{s0}c$. Using the CS constant again to eliminate e_s in Eq. (29) results in Eq. (30).

The theoretical significance of Eqs. (29) and (30) is discussed in Section 5. Equation (31) is a basic assumption of space–energy. Equation (32) defines a unit conversion constant, obtained by using Eq. (28) to eliminate e_s^2/ρ_{s0} in the expression for $(\mathrm{CS})^2$ and solving for ψ_0. In Eqs. (33) and (34) we see that χ^2 transforms $1/\epsilon_0$ into the energy density of free space (ψ_0) and μ_0 into the mass density of free space (ρ_{s0}). Equation (35) shows that χ also transforms the so-called electromagnetic impedance of free space $R_0 \equiv (\mu_0/\epsilon_0)^{1/2}$ into a basically directed or vector unit conversion constant Γ. As shown in Eqs. (36)–(38), Γ transforms the units of e, $\mathbf{E}$, and $\mathbf{D}$ into the units of e_s, $\mathbf{q}$, and $\mathbf{D}_s$. It is noted that the units of Γ given are also those of $\mathrm{W/m^2}$. Equations (39) and (40) simply show the formal correspondence that exists between the space–energy and em expressions for the far-field force on a charge and the energy density of the force field. Equation (41) simply recalls the fact that the classical electron radius r_e has been defined by equating the rest energy of an electron to its far-field energy. The value of r_* given in Eq. (42) results from equating the rest energy of an electron to the volume integral of $\epsilon_{\mathrm{em}}(r)$ taken from r_* to infinity. The result was obtained from a direct integration (by parts) of the equation $e^2/4\pi\epsilon_0 r_e \equiv m_e c^2 = 4\pi\psi_0 r_*^3 \int_0^1 [1 - H(\lambda)]\lambda^{-4}\, d\lambda$. The CS constant and Eq. (28) where then used to express r_* as an explicit function of r_e. We emphasize that the functional equalities and definitions given by Eqs. (29)–(40) are independent of the actual value of r_* itself and therefore the validity of the assumptions made in obtaining a numerical estimate for its magnitude.

5. ON THE PHYSICAL NATURE OF CHARGE AND TIME

In this section we discuss the shock wave physics and the structure of charge implied by the two equivalent source equations $e_s = 2\pi r_*^2 \rho_{s0} c = 2\alpha\hbar/r_*^2$, in conjunction with a physically consistent cosmological model of the universe. The resulting physical picture suggests that the expansion of our universe accounts for the fundamental origin of field-particles, and, hence, our perceptions of mass–energy in general or matter, space, and *physical time*. Physical time is here defined as the universal ordering and change parameter τ which, together with our mental abstraction of space, forms the basis for our descriptions of the space–energy fields and laws of nature in general. In this section we hope to illuminate two important theoretical aspects of space–energy. (1) That the abstract space required to provide an absolute description of space–energy field laws can be freely extended to as many dimensions $x^i = (x^1, x^2, x^3, \ldots, x^n)$ as seem necessary. (2) That space–energy field laws contain, in themselves, the inherent capability to establish a hierarchy of successively more encompassing and energetic spatial boundary conditions, covering a successively wider range of relatively secondary space–energy field laws and related physical phenomena in nature. This trend has already been observed in physics today, where we see binding energies increasing by a factor of about one thousand as we successively penetrate deeper theoretically and experimentally through the domains of atomic, nuclear, and now elementary particle physics. It is in this latter domain especially that we have come face to face with the seemingly paradoxial fact that particles become more fluid as they are given higher and higher amounts of energy, and yet there does not seem to be enough collision energy available to pull apart a single proton or electron. The suggested boundary condition responsible for this fact, and/or the effective size of elementary particles, is best illustrated by the following description of the way that a mass–energy fluid generates its own secondary boundary condition

Consider the flow rate **W** of mass–energy through a converging–diverging nozzle whose throat is defined by a minimum cross-sectional area A_*. Here it is well known that **W** can be *quantized* to a fixed value $\mathbf{W}_*$ by simply increasing the pressure ratio R across the nozzle until it equals or exceeds a *critical* value R_*. This phenomenon is a clear consequence of the fact that the velocity of the fluid (or gas) has reached the local velocity of sound at A_*. Consequently, pressure–density perturbations occurring downstream of A_* are trapped, and the physical *upstream world* then becomes isolated, in a very physical sense, from the happenings in the *downstream world.* Separating these two worlds is an extremely thin, but finite and relatively rigid or energy-rich wall, called a *stationary shock wave.* The shock thickness δ is proportional to the viscosity μ_* of the fluid and inversely proportional to $\mathbf{W}_*$, and it can be said that an otherwise seemingly inviscid mass–energy fluid will necessarily develop a small amount of viscosity as the pressure and density gradients in the shock tend to become infinite. In the last analysis, then, the spreading influences of viscosity and energy or heat conduction just balance the steepening influence of the pressure and inertia forces that would otherwise create a shock wave of zero thickness, and hence, a mathematical singularity in the description of mass–energy.[20] It would be incongruous to suppose that nature does not incorporate this beautiful characteristic of mass–energy to prohibit the occurrence of physical singularities on a more fundamental space–energy level.

In view of the above considerations, we predict that space–energy is entering and leaving the three-dimensional world of our *ordinary* sense perceptions via the elementary protons and electrons of our universe. The corresponding three-dimensional holes must therefore correspond to spherical shock surfaces or throats which are *stationary,* only with respect to a boundary condition in a fourth spatial dimension. We propose that this cosmological boundary condition may be viewed, consistently, as a spherically symmetric, cosmological shock wave or *hypershock*, expanding in a four-dimensional continuum of space–energy.[21] The description and visualization of such a phenomenon are facilitated by the fact that any phenomenon possessing spherical symmetry in an abstract four-space $x^i = (x^1, x^2, x^3, x^4)$ can be conveniently described in terms of four-dimensional spherical coordinates $(\xi, \psi, \theta, \phi)$, in complete analogy with similar circumstances in a three-dimensional conception of space. Valid mathematical analogies can then be drawn with a spherical two-dimensional shock wave expanding in our atmosphere. It is clear, however, that there are many things about a higher dimensional space which have no analogous representation in a lower dimensional space. Consequently, there should be many interesting surprises in store in the future as we learn to expand our capability to visualize more readily in terms of four spatial dimensions.

It helps in this regard to realize that our abstract four-space (x^i) is absolute and therefore positive definite, and that time τ can be regarded not as a fifth spatial dimension but rather as the physical expansion of a cosmological field-particle boundary condition in the direction of a fourth *curvilinear dimension* $\hat{\xi}(\psi, \theta, \phi)$. The general idea is, hopefully, to explain the abstraction of a seemingly fundamental ordering and change parameter τ called time in terms of a four-dimensional distance or curvature parameter R, where R describes the common four-dimensional distance $|\,\xi\,| = R$ to all points $P(\mathbf{R}, \psi, \theta, \phi)$ in the abstract (zero thickness) three-dimensional hypersurface $S_3(R)$, representing the position in four-space of the leading edge of our expanding hypershock universe. An understanding of this physical picture is facilitated by the following mathematical notations. The projections of $\mathbf{R} = R\hat{\xi}$ on the unit $\hat{\mathbf{x}}^i$ coordinates are just $x^1 = R \sin\psi \sin\theta \cos\phi$; $x^2 = R \sin\psi \sin\theta \sin\phi$; $x^3 = R \sin\psi \cos\theta$; and $x^4 = R\cos\psi$ (see Ref. 18, pp. 375–379). The four-vector $\mathbf{R}$ then sweeps out the abstract (zero thickness) surface $S_3(R)$ as the four-dimensional angle parameters are varied over the ranges $0 \leqslant \psi \leqslant \pi$, $0 \leqslant \theta \leqslant \pi$, $0 \leqslant \phi \leqslant 2\pi$. Any three-dimensional position-displacement vector $d\mathbf{r}$ lying in $S_3(R)$ and referenced arbitrarily to the four-point $P(\mathbf{R}, \psi, \theta, \phi)$ can then be conveniently resolved into the orthogonal curvilinear distances $d\xi_2 = R \sin\psi \, d\theta \, \hat{\boldsymbol{\theta}}$; $d\xi_3 = R \sin\psi \sin\theta \, d\phi \, \hat{\boldsymbol{\phi}}$; and $d\xi_4 = R \, d\psi \, \hat{\boldsymbol{\psi}}$; all of which are orthogonal of course, to the direction $\hat{\xi}(\psi, \theta, \phi)$ in four-space. The three-dimensional area of $S_3(R)$, denoted by the same symbol, follows directly from the simple integration $S_3(R) = \iiint d\xi_2 \, d\xi_3 \, d\xi_4 = 2\pi^2R^3$. The corresponding four-dimensional volume V_4 of space–energy enclosed by $S_3(R)$ is clearly just $V_4 = \int S_3(R)\, dR = \pi^2R^4/2$. Of this volume, the hypershock occupies only a thin four-dimensional shell of incremental volume $dV_4 = S_3(R)\delta = 2\pi^2R^3\delta$. The symbol dV_4 will be used accordingly as a mathematical symbol for the hypershock.

If we restrict the polar angle ψ to the value $\pi/2$, then instead of generating a great equatorial circle we generate a great equatorial two-surface within $S_3(R)$ and hence four-space, defined as $S_2(R)$. Except for the fact that R, ψ, θ, and ϕ are four-dimensional geometric parameters, $S_2(R)$ is described by the more familiar curvilinear coordinates (R, θ, ϕ), with its differential surface distances given by $d\xi_2 = R\, d\theta\, \hat{\boldsymbol{\theta}}$ and $d\xi_3 = R \sin\theta\, d\phi\, \hat{\boldsymbol{\phi}}$. Thus if the motion of mass–energy field-particles is generally constrained between the surfaces $S_3(R)$ and $S_3(R - \delta)$, then $S_2(R)$ and $S_2(R - \delta)$ are the boundaries of what we would tend to define empirically as an abstract (zero thickness) plane in the effective three-space of our ordinary experience. Our ordinary experience with matter and radiation would not therefore encourage us to suspect that any such plane in three-space has a physical thickness δ to it in the traditionally unobservable direction $\hat{\xi}$ of a fourth spatial dimension, and much less that space–energy, for no apparent cause, is flowing into this substratum, undergoing an intense thermodynamic change, and accelerating out of this substratum of three-space, as illustrated in Fig. 2. Such a phenomenon would in fact seem to violate all our commonsense notions of physical laws, unless we realized that this viewpoint of space–energy is very much like the splendid viewpoint that surfers obtain when they succeed in hitching a ride on an ocean wave. The analogy would be quite valid if we could only explain how the elementary particles of our universe are generated from and/or otherwise carried along with the hypershock. This is not as difficult as one might think.

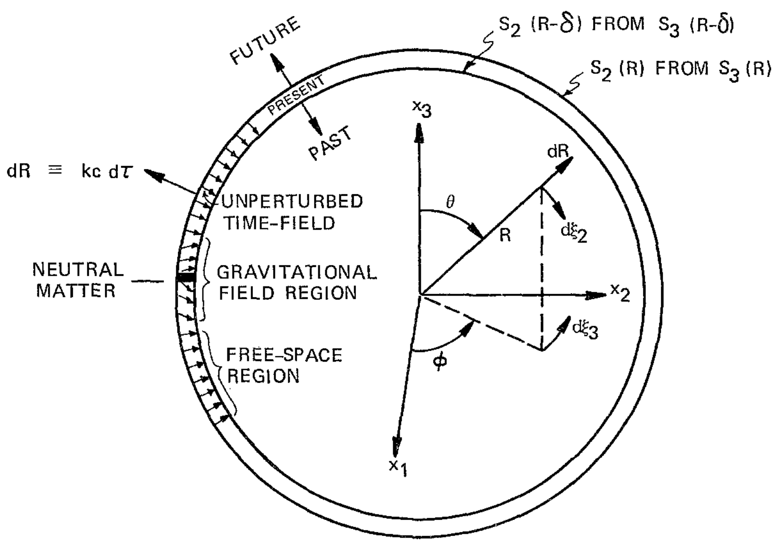

Fig. 2. The relationships among matter, space, gravitation, and time in a hypershock model of the universe, illustrated for an effective two-dimensional plane in the effective three-dimensional space of our ordinary experience.

Nor is it at all as simple as the following qualitative arguments might tend to suggest.

Vorticity ($\boldsymbol{\zeta} = \nabla \times \mathbf{q}$), and hence circulation, will be generated in space-energy even if its viscosity is taken to be zero, whenever and wherever the pressure gradient happens to become nonparallel to the gradient of the mass-density. At such points and times, vorticity will be generated, at least initially, at the rate $\partial\boldsymbol{\zeta}/\partial t = \nabla p_s \times \nabla(1/\rho_s)$ (see Ref. 16, pp. 83–87). Referring to Fig. 3a, we argue that there is a finite statistical probability $Q(R)$ for the rate of this occurring in the otherwise perfectly uniform radial flow of space-energy throughout the hypershock. Therefore $Q(R)$ governs the rate of formation of matter in the universe as a function of the curvature parameter R. Although it is basically irrelevant to the present line of reasoning, we might suppose that $Q(R)$ peaks significantly about a certain relatively small radius R_0 where (or when) most of the matter in the universe today originated. We then argue from entirely intuitive considerations that the generation of vorticity occurs predominantly at the shock surfaces $S_3(R)$ and $S_3(R - \delta)$, and that the resulting tendency to form a low pressure core causes a small amount of pinching of the radial flow field. We then argue that this only

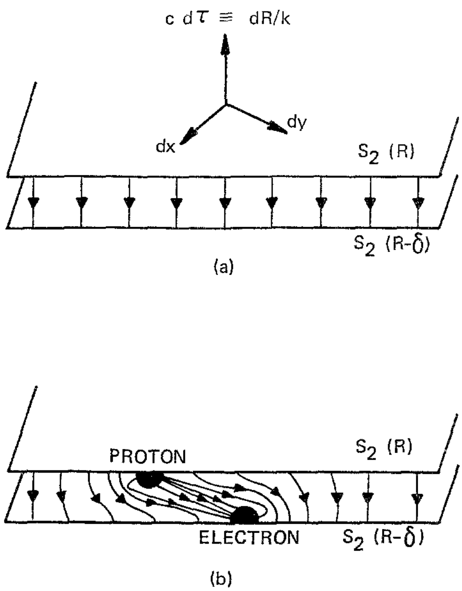

Fig. 3. The relationship between the quantized electrostatic field and the induced gravitational field of matter, illustrated for an effective two-dimensional plane in the effective three-dimensional space of our ordinary experience.

increases the value of the vector cross product above and hence the vorticity, which in turn causes a greater amount of space–energy flux to pass through the core of the vortex. This process is not imagined to be basically different from the way that mass–energy develops into a tornado, except that the role played there by the gravitational field is here replaced by the radial pressure and density gradients inherent in the hypershock itself. We then argue that the buildup of ζ is terminated at a value ζ_0 by the nonlinear mechanisms associated with occurrence of a Mach-one condition in the throat of the vortex, satisfying the equality $q = c' = 0.707c$ that was deduced in Section 4 on the basis of a very limited, three-dimensional and irrotational, analysis of charge. In this way it is clear that the amount of quantized mass-flux passing through the core or throat of an elementary particle would necessarily be related to the amount of intrinsic angular momentum of space–energy around the throat. If we imagine such a particle existing near the surface $S_3(R)$, we may say that the divergence of this flux into the effective three-space of dV_4 defines a "positively charged" elementary particle whose quantized flux $e_s = \Gamma e$ is governed by the fine structure equation $e_s = 2\alpha\hbar/r_*^2$. Consequently, we may conclude that $\hbar/2$ describes the empirical three-space angular momentum of space–energy associated with ζ_0, and that the quantity $4\alpha/r_*^2 = 1/34.26r_*^2$ is related to other four-dimensional thermodynamic properties like the Mach-one pressure and density gradients inside the throat. These latter properties could conceivably be expressed in the form $4\alpha/r_*^2 = (3/c^2)(\partial p_s/\partial r)_\parallel{}^*[\partial(1/\rho_s)/\partial r]_\perp{}^*$, where the subscripts $\parallel$ and $\perp$ denote directions parallel and perpendicular to the flow within the throat. We now argue that the fine structure relation $e_s = 2\alpha\hbar/r_*^2$ may be regarded as an invariant property or consequence of the thermodynamics of the hypershock, which is independent of the amount of internal mass–energy that may be otherwise contained within the throat of an elementary particle. Thus, with respect to the sandwich space of our universe defined by $S_3(R)$ and $S_3(R - \delta)$, we argue that protons and electrons can be regarded as literal *sources* (e_s) and *sinks* ($-e_s$) of a three-dimensional form of space–energy, which are entrained by the leading and trailing three-surfaces of our hypershock universe.

The corresponding origin of gravitation and the basic distinction between it and the electromagnetic field is described with reference to the proton–electron configuration shown in Fig. 3b, where the shock thickness δ has been grossly exaggerated in relation to r_* (as in Fig. 2 also) for the purposes of illustration. Here we see a four-dimensional side view or time view of the electric field between a proton and electron separated by a three-space distance of about $r = 6r_*$ and a time distance $\delta = 4r_*$. The representation of a flat three-space is consistent with the assumption that a three-space distance of 1000 light-years subtends an angle $\Delta\theta$ on the order of only 1 sec of arc. With a reasonable set of assumptions it can be shown that the convergent flow of space–energy from $S_3(R)$ to the smaller three-surface $S_3(R-\delta)$ requires an average acceleration of space–energy across dV_4 given by $\mathbf{a}_t = (-3k^2c^2/R)\hat{\xi}$, where $k = dR/c\,d\tau$ defines the present conversion factor between a world or free-space time interval $d\tau$ and the physical change $dR \equiv kc\,d\tau$. The acceleration field $\mathbf{a}_t$ is therefore designated as a *time-field*. The "electric" field lines in Fig. 3b depict the three-space and time distribution of that part of the time-field which is quantized and localized at points in three-space. The *external* field lines depict the corresponding fluid dynamic perturbation of the time-field in the four-space surrounding neutral matter. It therefore seems logical to suppose that the three-space component of this external time-field accounts for the gravitational acceleration field $\nabla(\frac{1}{2}q^2) \equiv (-GM/r^2)\hat{\mathbf{r}}$ deduced in Section 3. We argue, then, that the basic mathematical distinction between the electromagnetic and gravitational fields lies in the fact that the electromagnetic field originates essentially from a point source or sink whereas the source of the gravitational field is actually distributed along the hypershock boundaries throughout three-space, in such a way that the empirical energy density per unit mass $(-\phi = \frac{1}{2}q^2)$ drops off like $1/r$ rather than like $1/r^4$ as is expected for a point source of space–energy.

The foregoing considerations suggest that despite the present theoretical assertions to the contrary, it might be feasible to reconsider the neutron once again as a bound proton–electron state rather than as a fundamentally different field-particle. On the one hand, it seems reasonable to suppose that $\delta << r_*$, so that we could not reasonably expect to find the neutron's electron completely aligned with the neutron's proton in the four-direction $\hat{\xi}$. However, the mere existence of a finite δ would create room for previously unimagined particle binding states and perhaps a better understanding of the numerous empirically defined quantum parameters that now exist. In view of the highly advanced state of experimental and theoretical particle physics that exists today, one has to ask if there are any peculiarities associated with the physics of neutron–proton collisions or the so-called neutron–proton exchange force that would suggest the existence of a basic substratum and physical asymmetry in space of the kind that has here been described? A seemingly affirmative response to this question is found in the following statement made by Dürr and reported in Heisenberg's recent book[22]:

> "It seems that here we come face to face with very general and most important relations that we had failed to take into consideration. If one of nature's fundamental symmetries is regularly found to be disturbed in the spectrum of elementary particles, the only possible explanation is that the universe, i.e., the substratum where the particles originated, is less symmetrical than the underlying physical law. It follows that there must be forces acting over long distances, or elementary particles of vanishing inertial mass. This is probably the best way of interpreting electrodynamics. Gravitation, too, could arise in this way, so that here we may hope to find a bridge

to the principles on which Einstein wanted to base his unified field theory and cosmology... At present it looks very much as if we can interpret the whole of electrodynamics in terms of the asymmetry of the universe vis-à-vis the proton–neutron exchange or more generally vis-à-vis the isospin group."

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ADDENDUM:

Var R. 1975 On a New Mathematical Framework for Fundamental Theoretical Physics. *Foundations of Physics*, **5**(3), 407–431.

Page 420, Eq. (21): Replace; $\psi/\psi_0 = c'/c =$, with; $\psi/\psi_0 = \rho_s/\rho_{s0} = c'/c = 1/\gamma$

Page 421: Replace the last sentence of the top paragraph with: Equate the maximum flux of D_s defining $e_s = 4\pi(r^*)^2 D_s{}^* = 2\pi\rho_{s0}c(r^*)^2$ to the spatially varying flux $e_s = 4\pi r^2 D_s = 4\pi\rho_{s0}cr^2(u/\gamma)$, square, and solve for

$$u^2 = \{1 - (1 - \lambda^4)^{½}\}/2, \text{ with } \lambda = r^*/r,$$

which correctly reduces to $u^2 = (u^*)^2 = 1/2$ for $\lambda = 1$ and to $u^2 = 0$ for $\lambda = 0$. And using this radial variation of u^2 obtain

$$1/\gamma \equiv H(\lambda) = [\{1 + (1 - \lambda^4)^{½}\}/2]^{½}$$

and hence the radial variation of $\in_{em}$ in the form

Page 422:

Eq. (29). Replace $2\alpha\hbar$ with $2\alpha\hbar c$.

Eq. (32). Replace; [1.05×10^5, with [1.05×10^{10}] (a pure typo).

Eq. (33). Replace 4.14×10^{30} with 1.3×10^{31}, for the energy density (J/m^3) of the gravity-free 3-space of the universe.

Eq.(34). Replace 1.38 with 1.45

Historical Note: It was since learned via [23] and acquisition of [24] that Eq. (33) — to the extent that it be found to be approximately valid — validates James Clerk Maxwell's 1865 deduction that "every part of this medium possesses, when undisturbed, an enormous intrinsic energy" which "the presence of dense bodies influences so as to diminish it wherever there is a resultant attraction." Thus causing Maxwell to say, "As I am unable to understand in what way a medium can possess such properties, I cannot go any further in this direction in searching for the cause of gravitation." In our forthcoming papers in the Royal Society we intend to show how the concept of Maxwell's Stress Energy Tensor facilitates that answer.

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January 6, 1976

Prof. Werner Heisenberg
Max Planck Institute for Physics and Astrophysics
Max-Planck Gesellschaft zür Förderung der Wissenschaften
Föhringer Ring 6
8 Munich 23
GERMANY FR

Dear Prof. Heisenberg:

Prof. Yourgrau asked me to send you his best regards along with a reprint of my recent publication. *

Unless we are mistaken, it deals with the discovery of an unexpectedly useful mathematical physics for field-particle structure, and the kind of unified field theory and cosmology that Einstein favored. It also appears to offer a physical basis of explanation for the rather important conclusions expressed by Hans Dürr in your recent book, "Physics and Beyond".

If you concur that the theoretical principles and basic philosophy are sound, then we would be most grateful for any help that you could give us in bringing the article to the attention of a much larger audience of theoretical physicists. △

Very truly yours,

Robert E. Var

Robert E. Var
Staff Physicist

REV/pa

* R.E. VAR, "ON A NEW MATHEMATICAL FRAMEWORK FOR FUNDAMENTAL THEORETICAL PHYSICS," Foundations of Physics, VOL 5, NO. 3, SEPTEMBER 1975, PP. 407-431.

△ SEE Werner Heisenberg, "The [surprisingly Classical Dynamical] Nature of Elementary Particles," Physics TODAY, March 1976, PP. 32-39.