A “new and simple idea”, dark matter-energy and the crisis in physical theory

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Abstract. *Correction of an omission in A. Einstein’s operational definitions of time and space intervals in the special theory of relativity leads to an improved phenomenological and conceptual foundation for a previously proposed unified field theory. In combination with Einstein’s researches on the fluctuation in energy of black body radiation, there results a “new and simple idea” of the kind Professor Richard Feynman felt to be necessary for the solution of the cosmological constant problem. A brief description of the formalism of the theory is presented. The infinite zero-point energy of the vacuum is eliminated. A model for the origin of inertial mass and dark matter-energy is deduced. The resulting relation between observed matter and dark matter-energy leads to a restriction on their magnitudes. The magnitudes of the latter quantities are then estimated from astronomical data. A model is proposed for the origin of the gravitational field in terms of a dynamic process at the basis of the proposed theory. The success of the special theory of relativity in predicting the results of three crucial observations establishing the validity of the general theory of relativity and the elimination of the infinite vacuum energy suggest that the unified field theory can lead to a solution of the cosmological constant problem.*

Key Words: unified field, inertial mass, dark matter, gravity model, cosmological constant

1. INTRODUCTION

The late Professor Richard Feynman called for a "new and simple idea" [1] in connection with the cosmological constant problem [2]. The problem arises in the evaluation of a constant introduced into the equations of motion of the general theory of relativity (GTR) [3] and is related to the expansion of the universe [4].

Since the constant appears in a theory based on a model of the origin of the gravitation field, attempts at a solution of the problem necessarily involve phenomena on a cosmological scale. On the other hand, its relation to the expansion of the universe has brought into consideration the zero-point energy density of the vacuum [4], dark matter [2], and the nature of inertial mass [2], implicating subatomic phenomena.

Commenting on the connection between the latter topics, Professor Feynman pointed out that the zero-point energy in a vacuum would be expected to generate a gravitational field: instead "it is zero" [1]. As a consequence, Feynman suggested that the "new and simple idea" should also reformulate modern physics so that there is no zero-point energy in a vacuum [1]. Indeed, analysis of observations by the Hubble telescope has supported Professor Feynman's belief in the lack of any objective existence of zero-point vacuum energy [5, 6].

The need for a solution to the cosmological constant problem has been characterized as a "veritable crisis" in physical theory [7] whose solution may be expected to have a considerable effect on physics as well as astronomy.

This paper proposes a "new and simple idea", based on experiment, for the analysis of cosmological phenomena which meets Feynman's goal and is in accord with [5,6]. The discussion emphasizes physical models, rather than a mathematical formalism, although an abbreviated mathematical basis for these models is provided. The theory has been discussed in more detail in several papers [8-10] for subatomic, atomic and terrestrial phenomena with a slightly different (but equivalent) basis, with the same formalism as presented below. It has been shown to lead to a unified field theory (UFT) of a matter-radiation field, reducing in the proper contexts to the Maxwell electromagnetic field, Newtonian and relativistic mechanics and quantum mechanics. A model for the origin of the gravitational field was also included. It was shown that the infinite zero-point vacuum energy can be eliminated, as well as other infinities which have long been characteristic of a zero separation of test body and classical field source.

2. POINT OF VIEW OF THE UNIFIED FIELD THEORY

The point of view in the formulation of the UFT is based on observation: a viewpoint diametrically opposed to the approach employed in Einstein's unified field theory [11]. In a general vein, Einstein states "…this axiomatic basis of theoretical physics cannot be extracted from experience but must be freely invented and can we ever hope to find the right way?...I am convinced that we can discover by means of purely mathematical constructions and the laws connecting them with each other, which furnish the key to understanding of natural phenomena…in a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed" [12]. Further, Einstein's emphasis on mathematics and deduction as a source of inspiration for the creation of a new physical theory is summarized in his remark that "…the creative principle resides in mathematics" [12].

The latter point of view has permeated theories subsequent to the GTR, especially as they relate to a model for the gravitational force field. That is, the field is assumed to be identified with the curvature of the space-time metric---a geometrical property, rather than due to a physical dynamic process.

In contrast, we propose an alternative model for the origin of the gravitational force field resting on properties of subatomic phenomena, rather than on an intrinsic property of the space-time metric. This is expected to facilitate a unification of gravitation and the other three fundamental forces in nature---the electromagnetic, strong and weak forces.

.Further, the point of view adopted in the formulation of the UFT is in accord with a tenet advanced by H. Reichenbach, in his support of A. Einstein's original formulation of the special theory of relativity (STR) [13]. Based on a belief in logical positivism, it is asserted that, in advancing a physical theory, it is best to proceed by induction, in contrast to Einstein's dependence on deduction in [12].

H. Minkowski is more forceful in this regard: "My views of space and time have sprung from the soil of experimental physics and therein lies their strength." [14].

In addition, P. Bridgman states, in support of the STR [15], that every quantity introduced in a physical theory should have an operational definition, an opinion we shall implement below for the UFT. In this connection, we remark that such a requirement evidently can profoundly affect the interpretation of the data recorded, as, for example, the alteration of the length of a body when in motion relative to the observer. Such an effect would not necessarily be observed were it not for the manner of measuring length as specified in the STR, i.e. by means of light signals [16].

The "simplicity" of the idea to be proposed lies in taking over the essential concepts and thought experiments of the STR. The "new" aspect of the idea refers to the alteration of the light signals used in the STR, in accord with the implications of [17] and

[18]: that is, the fluctuations in intensity intrinsic to black body radiation are assumed to be a property of radiation propagated in a vacuum. The latter assumption is similar to that made by A. Einstein in [17] and [18] with respect to a quantum energy exchange property. Moreover, to preserve logical and measurement consistency in the operational definition of a linear length in the STR, it is necessary to define coordinate magnitudes by means of light signals, i.e. for a zero, as well as nonzero relative velocities of coordinate systems.

In accord with [17-19], it is noted that the fluctuations in radiation intensity increase as the scale of measurements in space and time decreases.

The emphasis on the importance of radiation fluctuations is not only justified by [17-18], but also by researches in quantum mechanics, quantum electrodynamics and random electrodynamics [20]. It has also been shown that the formalism of nonrelativistic quantum mechanics is equivalent to classical mechanics on which is superimposed a random walk [21].

4. ALTERATION OF THE MINKOWSKI METRIC

As a consequence of the foregoing considerations, the average, observed, arrival time of a light signal t becomes $t-t_0$ where t_0 is a random variable such that $-\infty < t_0 < +\infty$ with a vanishing average value: $\langle t_0 \rangle = 0$. The nature of the statistical distributions to be used in this connection has been indicated elsewhere [8, 9].

Owing to the latter considerations, the equation descriptive of the propagation of a light signal along the x-axis of a rectangular Cartesian coordinate system becomes $x-x_0 = c(t-t_0)$ where x_0 varies over the same range as t_0 and with vanishing average value and c denotes the speed of light in a vacuum. Similar relations hold for the y and z coordinates.

When the above alterations are applied to the Minkowski metric of space-time

$$s^2 = x^2 + y^2 + z^2 - c^2t^2 \qquad (1)$$

and averaged, we find (where $r^2 = x^2 + y^2 + z^2$, for example)

$$\langle S^2 \rangle = r^2 - c^2t^2 + \langle (r_0)^2 \rangle - c^2 \langle (t_0)^2 \rangle \qquad (2)$$

The latter calculation suggests replacing the metric (1) by

$$S^2 = r^2 - c^2t^2 + (r_0)^2 - c^2(t_0)^2 \qquad (3)$$

Setting $S = 0$ yields an equation descriptive of the propagation of a spherical light signal, subject to a fluctuation motion. Further physical interpretation of the metric (3) will be provided in Section 5.

The metric (3) is spatially flat (i.e. Euclidean) in agreement with observation [22].

In addition, the metric (3) is invariant under the Lorentz transformation:

$$\begin{aligned}
x' &= \gamma(x - \beta ct) \\
y' &= y \\
z' &= z \\
ct' &= \gamma(ct - \beta x) \\
(x_0)' &= \gamma(x_0 - \beta ct_0) \\
(y_0)' &= y_0 \\
(z_0)' &= z_0 \\
(ct_0)' &= \gamma(ct_0 - \beta x_0)
\end{aligned} \qquad (4)$$

where $\beta = v/c$, $\gamma = 1/\sqrt{(1-\beta^2)}$ and v is equal to the relative velocity of two observers moving parallel to the x-axis.

Evidently the transformation (4), applied to the differences $X=x-x_0$, $Y = y-y_0$, $Z = z-z_0$ and $cT = c(t-t_0)$, results again in the invariance of the metric

$$S^2 = X^2+ Y^2 + Z^2 - c^2T^2 \tag{5}$$

where X,Y,Z and T are random variables such that $<X> =x$. $<Y> = y$, $<Z> = z$ and $<T> = t$. Subtracting the second set of four equations in (4) from the first set of four equations yields a Lorentz transformation for the quantities X, Y, Z and T directly. Under the latter transformation the metric (5) is again invariant. In this case, however, X, Y, Z, and T contain "hidden" variables, and, together with the metric, can serve as part of a basis of a formalism for relativistic quantum mechanics. For the latter formalism, expectation values are calculated for a matter-energy (i.e. unified) field and not with the aid of a probability field which has no physical existence.

The differential form of the proposed metric (3) is

$$dS^2 = dr^2 - c^2dt^2 + (dr_0)^2 - c^2(dt_0)^2 \tag{6}$$

No quantization postulate has been introduced in the above discussion. This omission is supported by the derivation of the black body radiation energy spectrum without such a postulate; Lorentz invariance was, however, found to be essential [23].

5. MOMENTUM AND ENERGY OF THE UNIFIED FIELD

The following definitions have been chosen to parallel those of the STR [3]. In addition, it is found that the resulting formalism reduces to the STR in a suitable context.

Given some identifiable feature of the field described by the metric (6) at the point $(x,y,z,t,x_0,y_0,z_0,t_0)$, we define momentum components along the coordinate axes by

$$\mathbf{p} = m(d\mathbf{r}/d\tau) \text{ and } \mathbf{p}_0 = m(d\mathbf{r_0}/d\tau) \tag{7}$$

where $\mathbf{r} = (x,y,z)$, $\mathbf{r_0} = (x_0,y_0,z_0)$, $d\tau = +\sqrt{(dt^2-dr^2/c^2)}$, and energies

$$E = mc^2(dt/d\tau) \text{ and } E_0 = mc^2(dt_0/d\tau) \tag{8}$$

and where m is a factor with the dimensions of mass, whose nature will be clarified below.

Inserting the condition that neighboring observers can communicate with one another, i.e. $dS = 0$, into equation (6) and dividing the resulting equation by $d\tau^2$, we find

$$p^2 + (p_0)^2 = (E/c)^2 + (E_0/c)^2 \tag{9}$$

If the average displacement dr of the given feature be set equal to zero, then $d\tau = dt$ and

$$E = mc^2 \tag{10}$$

and

$$(p_0)^2 - (E_0/c)^2 = (mc)^2 \tag{11}$$

In view of equations (10) and (11), we interpret m as the rest mass of the given feature of the UFT field, generated by the fluctuating motion of the field. This motion is proposed to be the origin of inertial mass.

In the opposite extreme, we set $dr = c\, dt$, implying that $dr_0 = c\, dt_0$. This state of motion is readily interpreted as a light signal accompanied by fluctuations propagated with the speed of light c.

In view of the properties of the extreme conditions of motion, indicating a duality in the nature of the UFT field, we propose that matter be denoted as "condensed radiation" and radiation be denoted as "dispersed matter".

At intermediate average speeds, the given feature of the field can be expected to have both matter and radiation properties.

In view of the latter mass and radiation properties of the field introduced, we call it the “matter-radiation field”. Its ability to incorporate many other fields in its formal structure [8-10] leads to its designation as a “unified” field.

It is noted that the concept of a spherical light signal of the STR has been replaced by a spherical signal which includes matter states as well as radiation states; that is, two events may be connected by matter as well as radiation properties. In contrast, the spherical light signal of the STR refers solely to radiation.

The model corresponding to the above considerations implies that all observed matter and radiation is accompanied by fluctuations in energy with matter and radiation properties.

There is evidently a close analogy between the latter model and the concept of vacuum energy. We therefore propose that the vacuum zero-point energy concept be replaced by the UFT model, which is Lorentz invariant and yields finite results; it is not an intrinsic property of space-time, in accord with observation [5,6]. Moreover, the useful deductions sometimes held to be evidence for the objective existence of the zero-point vacuum energy (e.g. the Casimir Effect) can be preserved with the latter revision, since it is acknowledged that their explanation relies on energy fluctuations, rather than on the background energy [24].

6. DARK MATTER-ENERGY

Since the averaged, observed, motion of matter and energy, characterized by the four – vector ($\mathbf{p}$, E/c), is accompanied by a fluctuating motion described by the four-vector ($\mathbf{p_0}$, E_0/c), giving rise to inertial mass-energy(see eq. 11), we propose that dark matter and energy are root-mean-square consequences of the latter motion of the unified field.

In this connection, Professor Steven Weinberg has called for an explanation of why dark energy (here $\sqrt{[<(E_0)^2>]}$ is the same order of magnitude as energy in observed matter, i.e. $E = mc^2$ [25], implying that each acts as a constraint on the other.

The latter approximate equality becomes plausible in view of equations (10) and (11) and the proposed origin of dark matter-energy. Since Professor Weinberg specifies more closely that $\sqrt{<(E_0)^2>}$ is of the order of $2mc^2$, we deduce from (11) that $\sqrt{<(p_0)^2>}$ is approximately equal to $(\sqrt{5})(\sqrt{[<(E_0)^2>]}/c$. this relation is to be compared with the condition for observing radiation alone for which the factor $\sqrt{5}$ (approximately 2.24) is replaced by unity. These relations, then, may be an aid in formulating an explanation for the observed magnitudes of dark energy and matter and illustrate the usefulness of the "new and simple idea".

7. A MODEL FOR THE ORIGIN OF THE GRAVITATINAL FIELD

The following discussion proposes a mechanism for the origin of the gravitational field based on the UFT's inertial mass model and the principle of le Chatelier [26] (which states, essentially, that if a small perturbation be applied to a system in equilibrium, its parameters change in such a way as to restore equilibrium). It offers the possibility of removing the specialized role of the gravitational force in the GTR (i.e. a geometrical model, identified with the curvature of space-time), while the other forces in nature are held to be due to physical processes. The latter disparity hinders a unified representation of all these fields.

The Newtonian gravitation field exists in the presence of matter and not otherwise. It has been observed that all matter is composed of subatomic particles and therefore gravitation is a property common to and originating in these. Consistent with equations (10) and (11), we view these particles as bound states of the matter-radiation field with an internal motion described by equation (11), and with most of its mass m confined to a spherical region with diameter h/mc, where h denotes Planck's constant. It is assumed that these particles are stable during the period of observation in accord with a similar assumption about the macroscopic state of matter in Newton's law of gravitation. In effect, then, one is dealing with a physical system with internal fluctuations in energy analogous to a gas at a uniform temperature, composed of randomly moving molecules. These concepts are the basis of the following approximate analysis.

Consider first a single mass particle-field of mass m. When a second particle-field is brought into the neighborhood of the first, the inertial mass of the first field increases to $m+\Delta m$ (we assume that $\Delta m/m$ is very small compared with unity) so that, by le Chatelier's principle, the new equilibrium diameter of the field becomes essentially $h/(m+\Delta m)c$, or approximately $(h/mc)(1-\Delta m/m)$ and mass energy (including that from the second particle-field) will tend to flow toward the center of the first particle-field. Assuming that each particle-field retains its identity, there will be generated a force tending to move the second particle towards the first. A similar argument applies to the second particle-field so that there is a mutually attractive force urging the two particles together.

The equations of motion of the UFT for a point source of a static field (i.e. assuming a a Newtonian type of field) requires that the field potential be proportional to 1/r, where r represents the distance between source and test body.

We are then led to the plausible assumption that the force exerted by a subatomic particle on another subatomic particle by reason of its internal random motion,, and at a distance greater than a Compton wavelength, can be identified with the Newtonian law of gravitation.

8. THE COSMOLOGICAL CONSTANT PROBLEM

The severity of the cosmological constant problem becomes apparent upon comparison of estimates of the constant from cosmology, limiting its absolute value to less than 10E-56 cm^{-2}, while estimates based on zero-point energy (i.e. modern particle physics) differ from this limit by forty orders of magnitude [27]. Further evidence of the deep division between the two theories lies in Professsor Feynman's remark that zero-point energy has no gravitational effect (and therefore no point of contact with the GTR), while the GTR has little to say about modern particle physics. At minimum, then, it would appear that a unifying physical model which leads to a finite replacement for zero-point vacuum energy, as well as a model for the origin of the gravitational field, would be a promising candidate for resolving the cosmological constant problem. A further complication to be resolved is that particle theory is often discussed in terms of the STR with an implicit assumption that all coordinate reference frames are in uniform relative motion, while the GTR deals with accelerated frames of reference.

To be sure, for sufficiently small regions of space-time, the GTR can be approximated by the STR [28]. Moreover, it has been shown that calculations establishing the validity of the GTR for three crucial observations can be replaced by estimates based on the STR. These are: [29], for the red shift in radiation emitted by atoms in a strong gravitational field and the deflection of a light ray passing the sun, as well as [30], for the magnitude of precession of the perihelion of Mercury's orbit.

As a consequence, it would appear that if the UFT be added to the capabilities of the

STR, with a consequent unification of particle and gravitational field theory, there could result an improved estimate of the cosmological constant, consistent with both theories.

9. SUMMARY

The preceding discussion has had two principal objectives:

The first objective was to show that, since the special theory of relativity is based on operational definitions using clocks and realistic light signals, the definition of space-time coordinate intervals must include the effect of light signal energy fluctuations on their magnitudes. This requirement is a *necessity* for the logical consistency of any resulting theory and leads in a natural way to a unified field theory which contains previously derived theories and their useful consequences.

The second objective was to show how the referenced unified field theory, when applied to cosmology, can serve as the "new and simple idea" felt to the necessary by Professor Richard Feynman for solution of the cosmological constant problem. As demonstrated above, the theory meets Feynman's principal requirement that the infinite energy density of the vacuum be eliminated. From the expressions derived, it is then shown that there follows an explanation for the origin of dark matter and why it is of the same order of magnitude in energy as observed matter: an answer to a question posed by Professor Steven Weinberg.

Since the unified field theory lacks the infinities associated with the special theory of relativity, it is expected that it can aid in solution of the cosmological constant problem. especially since the fluctuations in matter-energy can be linked to observation through equation (11).

References

1.P. Davis and J. Brown, *Superstrings, A Theory of Everything (*Cambridge University Press, New York, 1988).

2. A.H Guth, *The Inflationary Universe (*Addison-Wesley Publ. Co., New York, 1942).

3. P.G, Bergman, *An Introduction to the Theory of Relativity* (Prentice-Hall, Inc., New New York, 1948).

4. M. Roos, *Introduction to Cosmology*, 2nd Ed. (Jon Wiley and Sons, New York, 1997).

5. R. Ragazzoni, M. Turato and W. Gaessler*, Astrophys. J.* **587,** L1 (2003).

6. R.R. Britt, http://www.space.com/scienceastronomy/quantum_hits_030402.htm

7. S. Weinberg, *Rev. Mod. Phys.* **61,** 1 (1989).

8. F. Alzofon in AIAA/SAE/ASME 17th Joint Propulsion Conference, 1981, Colorado Springs, AIAA-81-1608.

9. F. Alzofon, *Phys, Essays* **6**, 599 (1993.

10. F. Alzofon, *Phys. Essays* **14**, 144 ((2001).

11. A. Einstein, *The M eaning of Relativity,* 3rd Ed. (Princeton University Press,, Princeton, N.J., 1950).

12. A. Einstein, in *Essays in Science* (The Wisdom Library, The Philosophical Library, New York, 1934).

13. H. Reichenbach, in *Albert Einstein, Philosopher Scientist,* Ed. P. Schilp, (Open Court, La Salle, IL, 1970)

14. H. Minkowski, in *The Principle of Relativity* (Dover, New York, 1952).

15. P.W. Bridgman, in *Albert Einstein, Philosopher Scientist*, Ed. P. Schilp (Open Court,

16. A. Einstein, in *The Principle of Relativity* (Dover, New York, 1952).

17. A. Einstein, *Phys. Zeits.* **10**, 185 (1909).

18. A. Einstein, *Phys*. *Zeits*. **10**. 817 (1909).

19. L.D. Landau and E.M.Lifschitz, *Statistical Physics*, 3rd Ed., Part 1, Course of Theoretical Physics, Vol. 5 (Pergamon Press, New York, 1982).

20. T.H. Boyer, *Phys*. *Rev*. **11**, 790 (1975).

21. E. Nelson, *Phys*. *Rev*. **150**, 1079 (1969).

22, P. de Bernardis, P.A.R. Ade, et al. *Nature* **404**, 955 (2000).

23. T.H. Boyer, *Phys*. *Rev*. **150**, 1374 (1969).

24. T. Padhmanabhan, *Class*. *Quant*. *Grav*. **22**, L107 (2005).

25. S. Weinberg, http://supernova.lbl.gov/cylinder/weinberg.ps.

26. *McGraw-Hill Dictionary of Physics and Mathematics*, Ed. D.N. Lapedes (McGraw-Hill Book Co., New York, 1978).

27. S.E. Rugh and H. Zinkernagel, in *History and Philosophy of Science*, Part B, **33**, 663 (2002).

28. W. Pauli, *Theory of* Relativity (Pergamon Press, New York, 1958).

29. L.I. Schiff, *Am*. *J*. *Phys*. **28**, 340 (1960).

30. R.J. Buenker, *Apeiron* **15**, 509 (2008).

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