A PHOTON-NONPHOTON UNIVERSE

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ABSTRACT

The use of a particular two-vector formalism to describe the mass-energies and momenta of point-like particles allows the existence of two basic particle types: photons and nonphotons, the speeds of the latter being less than photon speed. Invoking the requirement of likekind vector additivity in a preferred inertial frame (that in which the microwave background photons appear isotropic) suggests a symbiotic coexistence of the two types where the death of one type gives birth to the other. Since nonphotons are born from the fusion of photons, it is assumed that Bose-Einstein statistics determine the particle densities in an equilibrium mix of the two types. Equilibrium densities are derived on the basis that particle energies in the preferred frame be integer multiples of a tiny quantum ε. This yields the Planck curve for the photon spectrum and extends this curve into a surface defining the spectra of nonphotons. Photon densities are found to be smaller by a factor of $\sim\varepsilon/kT$ than those of the ethereal nonphotons. The small value of ε relative to the energies of photons in the T=2.73°K preferred frame allows an explanation of photon redshift in a non-expanding universe. This type of redshift also allows one to understand why an accelerating cosmos is implied should one assume Doppler effects are the only cause of redshift.

The ethereal nonphotons may play multiple roles in an infinite and static photon-nonphoton universe. Besides giving microwave background photons "something to be in equilibrium with", they may act to maintain the photon-like constituents of electrons, protons and neutrons in dynamic equilibrium as they move inside thin string-like annular regions; and, they may collide elastically with these photonic constituents of weighable bodies to explain the Newtonian gravity acting between such bodies. It is also noted that nonphotons might play a role that mimics that of some form of "dark matter" and another role that mimics a repulsive gravitational force between bodies made up of photonic constituents.

The likely value of ε and other features of a photon-nonphoton universe model are estimated, and experiments to test aspects of such a universe are suggested. The model leaves room to utilize the useful features of existing theories while simply avoiding the singularities yielded by solutions to continuum-type theories.

DEDICATED TO

RUTH GARNET WARE SAFONOV

my partner in life since 1938 who has encouraged, critiqued and typed this work as well as most of my various studies over the years.

ACKNOWLEDGEMENTS

The author wishes to acknowledge and express his appreciation to colleagues who have supported this work over the years. Dr. Tom Wilcox, Senior Scientist, has reviewed much of the work, checked many of our derivations and provided simple expressions for some of the integrals involved in defining properties of a photon-nonphoton universe. John Kirkwood has used his computer expertise to plot the mass-energy density equations of particles in an equilibrium photon-nonphoton mix. Steve Bicknell, Graphic Designer/Illustrator, has worked to finalize the figures and tables appearing in this document.

ABOUT THE AUTHOR

During a ten-year period straddling the WW-II years, George Michael Safonov studied and worked at the California Institute of Technology. There, he earned a BS(1943) in electrical engineering and an MS(1948) and a Ph.D(1949) in physics. During the war years, he worked on Caltech's rocket program (exterior ballistics); and, during the postwar years, he taught undergraduate physics.

In the 1950's and 1960's he concentrated on theoretical and experimental work on fission-chain reacting systems. He developed equations permitting the survey of critical parameters of the connected spectrum of fast to slow reactors and published in the proceedings of the second Atoms for Peace Conference his equations and surveys of a new class of reactors—the externally moderated systems. One such system, the cavity reactor, lent itself to the direct conversion of fission fragment energy to electricity. He demonstrated this conversion concept via experiments on cells irradiated at two neutron-source reactors. During the early 1970's he identified cavity reactor systems where fission fragments would pump high-power lasers. The fission-laser concept was later demonstrated by other workers using his basic cell design. Invited lectures on his various fission-related works were presented at Caltech, UCLA, UCB and also at Stanford where he supervised a Ph.D candidate's fission-fragment research. In the 1980's, he studied various peaceful and military applications of fission and the use of particle beams for missile defense.

Since his semi-retirement in the early 1980's, he has worked to bring into coarse focus important features of the unconventional universe model described here. That model, called the "photon-nonphoton universe", involves the symbiotic coexistence of two basic particle species: photons and nonphotons (i.e., photons fuse to form nonphotons which fission into photons). By combining old Caltech-era ideas on particles and the methodologies used for his fission-system studies with a simple approach to Planck's photon spectrum, a rough definition of a photon-nonphoton universe's features became possible.

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I. INTRODUCTION AND SUMMARY

An unconventional concept of the universe emerged in the course of a series of studies conducted since 1949 (Refs.1 through 10). Our purpose here is to combine the various papers on those studies into a single document to describe more efficiently the emerging universe model. We have come to refer to that model as the "photon-nonphoton universe".

A primary difference between the photon-nonphoton universe model and the conventional big bang models is that the latter considers an expanding universe while the former assumes a static universe. A big bang universe is presumed to be born from an energy-density singularity and to evolve through an inflationary epoch to achieve its present cosmological-scale uniformity. In contrast, if viewed on the grandest cosmological scale, the photon-nonphoton universe would always be seen to have a uniform density of constituent entities. Both types of models conform with certain observations, (e.g., a dark night sky and spectral Doppler shifts). However, the two types of models differ strongly in addressing puzzles raised by recent observations. For example, the static model explains strong redshifts without imposing the need for an accelerating expansion of a big bang universe. Such differences are noted in the body of this document, the contents of which we now summarize in brief.

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In Section II, we describe a two-vector formalism used to define the properties of the point-like particles assumed to make up all things in the universe. Formalism vector-length is defined in terms of a particle's mass-energy and momentum, which transform from one inertial frame to another according to the prescriptions of special relativity. And, these prescriptions thus define the formalism vectors appropriate to any particular frame. Photon-like particles have formalism vectors, **E** and **B**, that are equal in length. Particles with $|\mathbf{E}| \neq |\mathbf{B}|$ are called "nonphotons"; particles which have invariant rest mass and cannot be seen to move at photon or greater speeds in any frame according to the two-vector formalism. Because of certain limited similarities to the field vectors of electromagnetism, **E** and **B** are sometimes referred to as a particle's "electric" and "magnetic" vectors, respectively.

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In Section III, we turn our attention to particle fusion and fission events in a "preferred" inertial frame, referred to as the "universe frame". In that frame, the microwave background photons are seen to move isotropically and to have a $T \cong 2.73K$ Planckian energy spectrum. In the universe frame, we postulate conditions that particle formalism-vectors must satisfy if a pair of particles are capable of fusion or if the converse fission event may occur. Basically, the postulate requires that—in the universe frame—the **E** and **B** vectors of the fused particle be the sums of the like-kind vectors of the two incoming particles. And, a fission breakup of the fused particle represents the converse event. In other than the universe frame, this "law" for fusion or fission is expressible in terms of the observable velocity of such a frame relative to the universe frame. A possible experiment to determine a frame's relative velocity is described in Appendix A. And, the transformed fusion-fission postulate is examined in Appendix B. Since the universe frame offers the simplest examination of the fusion-fission processes, in Section III we consider these processes in that preferred frame.

It is shown that in the universe frame a nonphoton can only be formed by the headon meeting of photons with properly oriented formalism vectors and that subsequent fission would return the same photons to the universe. Also, it is shown that two equal-velocity particles with the same dominant formalism vectors properly oriented are capable of fusion; and, the converse fission process may occur.

We conclude Section III with brief remarks on spontaneous and photon induced fission of a nonphoton and on certain allowed and disallowed interactions between particle pairs.

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Section IV considers systems of photons and nonphotons in equilibrium. Since the universe frame has the characteristics of the uniform and isotropic phase space underlying conventional determinations of particle densities, we follow the usual pathway to determine those densities in that preferred frame. And, since two photons (bosons) fuse to form a nonphoton, we utilize Bose-Einstein statistics in determining the densities of photons and nonphotons in an equilibrium mix. In order to work with countable energy states, as required for a statistical analysis , we postulate that—in the universe frame—each particle's energy equals an integer times ε, a tiny quantum of energy. Following the approach used by Bose in developing the curve representing Planck's photon spectrum, we extend this curve into a surface which represents the spectra of nonphotons as well as photons, (Figure 6).

The photon number and energy densities are essentially independent of ε if $\varepsilon \ll kT$, a condition readily satisfied by a $T = 2.73K$ photon-nonphoton universe model, (Section VII). The ratio of the nonphoton-to-photon densities is of order of kT/ε, a number of order 10^{77} according to our Section VII findings. However, even though the nonphoton densities dwarf the photon densities, the average energies for these two particle species are comparable, being $\sim 10^{-3}$ eV for the $T = 2.73$K universe. The speed of the average nonphoton is seen (in the universe frame) to be $[1 - (3\pi/16)^2]^{1/2} \cong 0.81$ *times photon speed* (Table I). Useful properties of the average moving nonphoton are expressed as functions of kT/ε in Section IV. That section includes a listing of connections between certain fusion-fission event-probability parameters (e.g., event microscopic cross sections and nonphoton spontaneous fission probability per unit time) that are derived in Appendix C.

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In Section V, we show how photon redshift may occur in a static universe. Basically, as a photon emitted from a source travels to a detector, the tiny ε-quanta of the source photon are progressively lost via fusion with the quanta of microwave background photons. Half of the mass-energy of the tiny nonphoton debris equals that lost by the redshifted source photon. For small source-to-detector distances, this type of redshift is roughly proportional to distance. At large distances the redshift tends to increase exponentially with distance. Thus, a dark night sky is assured in an infinite static universe that is uniformly populated by photon sources. It is noted that if the near-exponential increase of redshift at large distances is used to compute a speed via the Doppler equation, the results might be interpreted as an acceleration of the rate of expansion of an expanding universe.

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In Section VI, we assume the bodies in solar-type systems present very thin targets to the ethereal nonphotons of 2.73K space. On this basis, it is demonstrated that the Newtonian gravitational force between bodies can be understood in terms of elastic collisions of the space nonphotons with the photon-like particles (photonics) making up such bodies of weighable (ponderable) matter. To accomplish the demonstration, the ethereal nonphotons and the photonics making up ponderable matter are represented by the average of each species. It is suggested that the generalization of Newtonian gravity to that of general relativity may result by going from thin to thick-target bodies in which each nonphoton might experience multiple elastic collisions with a body's photonic constituents.

To start, the force on the photonics in a unit volume of a body of ponderable matter under bombardment by a beam of nonphotons is developed. That force is proportional to a defined function, $f(\gamma)$, where γ represents the ratio of the momentum magnitude of a photonic to that of a nonphoton. If nonphoton gravity is to equal Newtonian gravity, we found that the quantity $\lambda^{-2} \times (kT/\varepsilon) \times f(\gamma)$ must equal a quantity proportional to the gravitational, constant G – – – the constant of proportionality being fixed by known properties of nonphotons (Eq. (95). The λ quantity represents the average number of grams/cm^2 of ponderable matter through which a nonphoton travels to experience its first elastic collision with a photonic. We assumed the uncertainty in the measured value of G is the result of second collisions in sun-like bodies. An uncertainty of one part in 10^5 (Ref. 13) corresponds to our assumed λ-value of 10^{16} grams/cm^2. This left the model's "central parameter" $K \equiv kT/\varepsilon$ and γ to be determined.

The parameter, K, is determined by use of the photonic ring model developed to represent the electron, proton and neutron and their antiparticles. Those models are explained in Appendix D, which builds on our 1949 considerations of such models (Appendix E). A photonic ring model of a nucleon, which conforms with a nucleon's mass and angular momentum, must be very thin relative to the ring radius for a λ-value of 10^{16} grams/cm^2. The ratio of ring-thickness to ring-radius must be $\sim 10^{-13}$ *if* solar type bodies, consisting mostly of nucleons, are to represent thin targets to nonphotons. And, if the ring surface perfectly reflects nonphotons so as to confine a nucleon's photonics in a state of dynamic equilibrium, the pressure felt by the surface must be of order of 10^{64} dynes/cm^2. This large pressure requires a value of $K = kT/\varepsilon \sim 10^{77}$; and, thus, a tiny ε quanta of order 10^{-81} eV.

By use of the λ and K values, computed as above, and the necessary condition expressed by Eq. (95) for nonphoton gravity to equal Newtonian gravity, we obtained a γ value of $\sim 10^{-19}$ via the known $f(\gamma)$ function. This completed our demonstration that Newtonian gravity could be understood in terms of elastic collisions between 2.73 Kelvin space nonphotons and the photonics that make up the thin-ring constituents of weighable matter.

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In Section VII, we utilize the values of the trio of parameters, λ, K and γ, yielded in our Section VI nonphoton gravity study. Those values permit us to define features of an emerging model of a photon-nonphoton universe. The ε-quanta constituency of the average nonphoton and the average photonic become definable. And, the photonic constituency of the electron, proton and neutron becomes definable (Table 2). The list of nonphoton features includes their number and inertial-mass densities, their directional flux and the large pressure felt by surfaces that perfectly reflect them. The list of photonic-related features includes their average energy and—if not neutral—their electrical charge.

With λ, K and γ values in hand, we become able to estimate the microscopic cross sections for the interactions between pairs of particles (e.g., the elastic collision of an average nonphoton with an average photonic constituent of a ponderable particle such as the electron, a nucleon or a photon). Also, the "redshift cross section" for the headon fusion of a pair of ε-quanta photons becomes definable. The mean free paths for each of the above two-particle events are determined by use of the associated microscopic cross section.

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In Section VIII, we briefly recall the path followed toward a construction of a photon-nonphoton model of the universe. Rationale for following that particular path is reviewed. How the model may answer questions raised by fairly recent observations is discussed. Also, we note that nonphotons may mimic the effects generally attributed to some form of dark matter and mimic the existence of a repulsive gravitational force. (Appendix F presents a brief discussion of such nonphoton roles.) And, a few possible experiments to test aspects of the model are noted.

II. PHOTONS AND NONPHOTONS

All things in the universe are assumed to be made up of point-like particles that obey the laws of special relativity. That is, we assume that a particle's properties seen in one frame relate to those seen in a second frame according to the frame-to-frame transformation prescriptions of special relativity.

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A two-vector formalism is employed to define the values of certain particle properties (e.g., velocity, inertial mass and momentum) as these properties would be seen in a frame of interest. These vectors are denoted by **E** and **B** and their lengths by E and B*. At least one of the vectors has a non-zero length; and, if both are non-zero, the two are perpendicular. In either case, a particle's formalism vectors satisfy

$$\mathbf{E} \bullet \mathbf{B} = 0. \qquad (1)$$

In terms of the formalism vectors, in units of c (the speed of light), a particle's velocity is given by

$$\boldsymbol{\beta} = 2\, \mathbf{E}\times\mathbf{B} \,/\, (E^2 + B^2). \qquad (2)$$

*Because of certain similarities between our formalism vectors and electromagnetic field vectors, we sometimes refer to **E** and **B** as the "electric" and "magnetic" vectors respectively.

Because of the normality requirement of Eq. (1), the particle's speed is expressed by

$$\beta = 2\,EB/(E^2 + B^2). \tag{3}$$

Thus, in accord with special relativity, the formalism limits particle speed to the range of $0 \leq \beta \leq 1$.

The formalism expresses a particle's inertial mass in units of ε/c^2, where ε is a tiny unit of energy, by

$$m = \mathbf{E} \cdot \mathbf{E} + \mathbf{B} \cdot \mathbf{B} = E^2 + B^2 \tag{4}$$

In units of ε/c, we denote a particle's momentum by $\mathbf{P}$. From the definition of momentum, we have

$$\mathbf{P} = m\boldsymbol{\beta} = 2\,\mathbf{E} \times \mathbf{B}. \tag{5}$$

Thus, in units of ε/c, the magnitude of a particle's momentum is

$$P = m\beta = 2EB. \tag{6}$$

It is noted that the formalism recognizes two distinct particles with the same inertial mass, m, and momentum-magnitude, P. This follows since m and P are not changed if we interchange the values of E and B. In terms of m and P, the vector lengths of these two particles are given by

$$E = (1/2)\,[\sqrt{(m+P)} \pm \sqrt{(m-P)}] \tag{7}$$

and

$$B = (1/2)\,[\sqrt{(m+P)} \mp \sqrt{(m-P)}]. \tag{8}$$

According to special relativity, in going from frame S to frame S', a particle's inertial mass and momentum-magnitude transform from m and P to m' and P'. In terms of S-frame quantities m' is given by

$$m' = (m - \alpha P \cos \psi)/\sqrt{(1 - \alpha^2)}; \tag{9}$$

m' and P' satisfy

$$(m')^2 - (P')^2 = m^2 - P^2 = m_o^{\,2}; \tag{10}$$

and

$$P' \sin \psi' = P \sin \psi. \tag{11}$$

Above, α is the length of the vector $\boldsymbol{\alpha}$, which is the uniform velocity of S' relative to S in units of c; ψ is the angle between $\boldsymbol{\alpha}$ and **P**; m_o is the rest mass of a particle capable of rest; and ψ' is the angle between $\boldsymbol{\alpha}$ and **P'**. The vectors $\boldsymbol{\alpha}$, **P** and **P'** are coplanar.

Of course, the $\beta = 1$ photons seen in S have $m = P$; and, thus, have $m' = P'$ in all S' frames. In this sense, photons have zero rest mass, m_o, and are incapable of rest. That is, $m' = P'$ in all frames; whence, photons are seen to move at $\beta'c = (P'/m')\, c = c$ in all frames according to the special relativity feature expressed by Eq. (10).

Since a particle's inertial mass and momentum magnitude are seen to be different in S and S', its formalism vector-lengths will also differ in the two frames. The lengths appropriate for S' are, of course, obtained by writing m' for m and P' for P in Eqs. (7) and (8). The lengths transform from S to S' so as to satisfy the invariance of m_o. That is, via Eqs. (4), (6) and (10), it follows that

$$E^4 - 2\,E^2B^2 + B^4 = (E')^4 - 2\,(E')^2(B')^2 + (B')^4 = m_o^{\,2}. \qquad (12)$$

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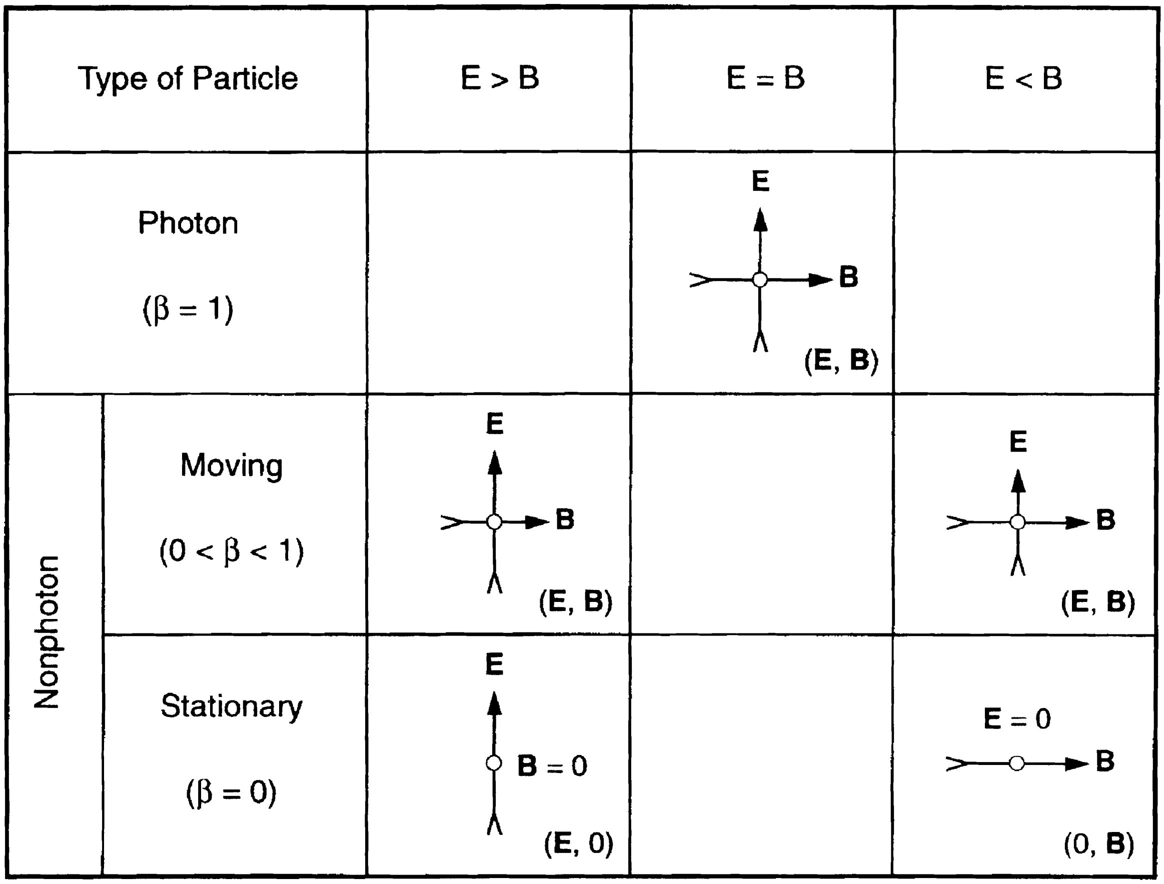
As evident from Eqs. (3) and (12), if E = B, then $\beta = 1$ and $m_o = 0$; and, we regard the particle as some kind of photon. The formalism also allows "nonphotons", particles with $E \neq B$. The nonphotons have β values in the range $0 \leq \beta < 1$ and have $m_o > 0$. As a consequence of special relativity transformations, photons "are seen" as photons; and nonphotons "are seen" as nonphotons in all inertial frames.

In what follows, we use the notations **E**,**B** to identify a particle with formalism vectors **E** and **B**. Figure 1 illustrates vector configurations that may serve to represent photons and nonphotons, the two classes of point-like particles assumed to make up all things in the universe.



Salonov, universe, fig1-4

Figure 1. Particle Vector Representations and (Symbols).

III. PARTICLE FUSION AND FISSION

The existence of a "preferred" inertial frame enables us to construct a photon-nonphoton model of an infinite universe. Observations have shown that the photons of the microwave background in the preferred frame are seen to be essentially of uniform density, to move isotropically and to exhibit a $T \cong 2.73K$ Planckian energy spectrum. Here, we refer to that frame as the "universe frame". Observers in frames that move at a velocity $\boldsymbol{\alpha}c$ relative to the universe frame will see the microwave background photons to be anisotropic. And, on the basis of such observations they will be able to determine their frame's "$\boldsymbol{\alpha}$-signature". A discussion of a particular experiment that might be used to determine a frame's $\boldsymbol{\alpha}$-signature is found in Appendix A. Below we consider certain interactions between photons and nonphotons as such would be viewed in the $\boldsymbol{\alpha} = 0$ universe frame. How these events would appear in an $\boldsymbol{\alpha} \neq 0$ frame is discussed in Appendix B.

We postulate that, in the universe frame, the formalism vectors of the three particles $\mathbf{E},\mathbf{B}$, $\mathbf{e},\mathbf{b}$ and $\boldsymbol{\mathcal{E}},\boldsymbol{\mathcal{B}}$ must satisfy

$$\mathbf{E} + \mathbf{e} = \boldsymbol{\mathcal{E}} \tag{13}$$

and

$$\mathbf{B} + \mathbf{b} = \boldsymbol{\mathcal{B}} \tag{14}$$

if the first two may fuse to form the third; or, if the converse fission event may occur.

The formalism vectors for each of the various particles must, of course, satisfy the normality condition of Eq. (1). This requires that

$$\mathbf{E} \bullet \mathbf{b} + \mathbf{e} \bullet \mathbf{B} = 0. \qquad (15)$$

The conservation of inertial mass energy requires that

$$\mathbf{E} \bullet \mathbf{e} + \mathbf{b} \bullet \mathbf{B} = 0; \qquad (16)$$

and the conservation of momentum requires that

$$\mathbf{E} \times \mathbf{b} + \mathbf{e} \times \mathbf{B} = 0. \qquad (17)$$

Equation (17) tells us: (i) that **E×b** must be equal and opposite **e×B;** or, (ii) that each of these vectors must vanish. If (i), the plane of **E** and **b** must be parallel to that of **e** and **B**. If (ii), **E** and **b** must be collinear; and **e** and **B** must be collinear. In either case, all the vectors—**E**, **B**, **e** and **b**—are parallel to a common plane, to which $\mathcal{E}$ and $\mathcal{B}$ must also be parallel according to Eqs. (13) and (14). Hence, we may draw the formalism vectors of two moving particles that are capable of fusion in the plane of the paper as shown in Fig. 2.

In terms of the formalism's vector-lengths, the three necessary conditions expressed by Eqs. (15, (16) and (17) become

$$(Eb \pm eB) \sin \varphi = 0, \qquad (18)$$

$$(Ee \mp Bb) \cos \varphi = 0 \qquad (19)$$

and

$$(Eb \mp eB) \cos \varphi = 0, \qquad (20)$$

where φ is the angle between **E** and **e** (Fig. 2). Fusion, of course, requires that the particles move collinearily to a meeting or be in stationary or moving contact. The upper sign in the above equations applies if the two particles move to a headon encounter (Fig. 2a). The lower sign applies if the particles fuse while moving codirectionally (Fig. 2b) or while seen to be stationary in the universe frame.

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For the headon encounter case, Eq. (18) can only be satisfied if $\varphi = 0$ or $\varphi = \pi$. In this case, Eqs. (19) and (20) can only be satisfied if E = B and e = b. That is, for headon fusion, both **E,B** and **e**,**b** must be photons. The particle formed by fusion is a nonphoton with $\mathcal{E} > \mathcal{B}$ if $\varphi = 0$ (Fig. 3a) or with $\mathcal{B} > \mathcal{E}$ if $\varphi = \pi$ (Fig. 3b). In units of ε, let N and n ($\leq$N) represent the energies of the two photons. In terms of these photon energies, the properties of the nonphoton formed by their fusion are given by

$$\mathcal{E} = \sqrt{(N/2)} \pm \sqrt{(n/2)} \qquad (21)$$

$$\mathcal{B} = \sqrt{(N/2)} \mp \sqrt{(n/2)} \qquad (22)$$

$$\mathcal{M} = (N + n) \qquad (23)$$

$$\mathcal{P} = (N - n) \qquad (24)$$

$$\beta = (N - n)/(N + n) \qquad (25)$$

and $$\mathcal{M}_o = 2\sqrt{(Nn)}. \tag{26}$$

The upper sign applies if $\varphi = 0$ and the lower if $\varphi = \pi$.

The formation of a nonphoton of mass-energy $\mathcal{M}$ and momentum $\mathcal{P}$ via the headon fusion of a photon pair requires that the photons have the unique energies

$$N = (\mathcal{M} + \mathcal{P})/2 \tag{27}$$

and $$n = (\mathcal{M} - \mathcal{P})/2 \tag{28}$$

and be oriented with $\varphi = 0$ or $\varphi = \pi$. Conversely, the only antidirectional pair of fission products that can emerge from the fission of the said nonphoton are the photons with the above energies. The pair of photons always leaves the fission scene antidirectionally along a line. This line coincides with that traveled by a moving nonphoton. If a nonphoton is stationary, two equal-energy photons may leave the fission scene antidirectionally along any line in the plane normal to the nonphoton's one formalism vector. Thus, the headon fusion of unequal-energy photons and their subsequent rebirth via fission serves to delay photon passage through a region. And, the headon fusion of equal-energy photons may serve to redirect photon motion.

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Where **E,B** and **e,b** are seen in the universe frame to move codirectionally, Eqs. (19) and (20) require that $\varphi = \pm\,\pi/2$ if the particles are to be capable of fusion, (Figures 4a and 4b). Satisfaction of Eq. (18) then requires that E/B = e/b. This tells us two things: (a) according to Eq. (3), the codirectionally moving particles must have the same speed; and, (b) if nonphotons, the particles must have the same dominant formalism-vectors. Since two separated particles moving along a line at the same velocity cannot meet to fuse, it follows that fusion requires that the two move in contact as one or be in stationary contact. In terms of the common particle-speed, β, and the mass energies, N and n, of the fusing particles, the properties of the particle formed by fusion are given by

$$\mathcal{E} = (1/2)[\sqrt{(1+\beta)} \pm \sqrt{(1-\beta)}]\,\sqrt{(N+n)}, \qquad (29)$$

$$\mathcal{B} = (1/2)[\sqrt{(1+\beta)} \mp \sqrt{(1-\beta)}]\,\sqrt{(N+n)}, \qquad (30)$$

$$\mathcal{M} = (N+n), \qquad (31)$$

$$\mathcal{P} = \beta(N+n), \qquad (32)$$

and

$$\mathcal{M}_0 = (N+n)\sqrt{(1-\beta^2)}. \qquad (33)$$

Above, the upper sign applies if electric vectors dominate and the lower if magnetic vectors dominate.

In the case of the fusion of stationary or codirectionally moving particles, it is evident that all particle pairs with $(N + n) = \mathcal{M}$ can fuse to form the same single particle. Conversely, the single particle of mass-energy $\mathcal{M}$ can fission into the number of pairs for which $(N + n) = \mathcal{M}$. That is, in contrast to the case of the fusion of antidirectional photon pairs, the same large $\mathcal{M}$ particle can be formed by a variety of pairs of codirectionally moving particles.

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The above rules governing fusion/fission of codirectional particles in the universe frame, allow one to regard the particle of speed β and with a mass-energy equal to an integer N as an ordered assembly of N fusible, unit-energy particles. In terms of β, the electric and magnetic vector-lengths of each of the N units would be

$$e = (1/2)[\sqrt{(1+\beta)} \pm \sqrt{(1-\beta)}] \qquad (34)$$

and

$$b = (1/2)[\sqrt{(1+\beta)} \mp \sqrt{(1-\beta)}], \qquad (35)$$

respectively. If the composite particle's electric vector dominates, the upper sign applies; otherwise the lower applies.

Consider a system of N identical particles, each with a mass-energy of unity and each moving in the same direction with a momentum of β (recall ε and ε/c are our units of energy and momentum). A single particle with mass energy N that moves in that direction at speed β, of course, has the same momentum, βN, as the system of N particles. If all particles have the same dominant formalism-vector, the lengths of the single particle's vectors, E and B, are related to those of the system's units, e and b, by $E = e\sqrt{N}$ and $B = b\sqrt{N}$, where e and b are given by Eqs. (34) and (35).

Imagine the electric vectors of the N units are connected in a head-to-tail fashion to form a chain of links. Let the two ends of the chain be separated by a distance of $e\sqrt{N}$. Independent of the orientations of the links of our Ne-long chain lying on a plane, the equalities of the system's and the single particle's mass-energy and momentum hold. However, for arbitrary orientations of the links, the system's units are not fusible into the single particle under consideration.

A necessary condition for fusibility is had if the orientations satisfy a certain rule. Let us number the units 1, 2, 3....., i....., N. Fusibility requires that unit-i's link makes the angle $\sin^{-1}(i-1)^{-½}$ with unit-(i-1)'s link—the direction of unit-i's link being taken as a reference direction. Figure 5 shows the orientations of the units in a fusible system of $N = 5$ units that move at speed $\beta = 3/5$. For a fusible group, it is noted that the lengths of the electric (magnetic) vector of the particle resulting from the progressive fusion of units number 1 through i is $e\sqrt{i}$ ($b\sqrt{i}$).

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Two types of nonphoton fission into antidirectional photons may be assumed to be allowed: spontaneous fission at a rate unaffected by the presence of photons; and, photon-induced fission. This latter type may be considered to result from the close collinear passage of the nonphoton by a "photon twin" of either of the two photons that could have fused headon to form the nonphoton. The induced fission event does not violate any of the above rules since it may be regarded as two independent processes. One, the twin photon approaches, passes and then leaves the fission scene without any change in its defining (formalism) vectors. Two, the nonphoton fissions while obeying all the rules (i.e., the fission occurs as if it were spontaneous).

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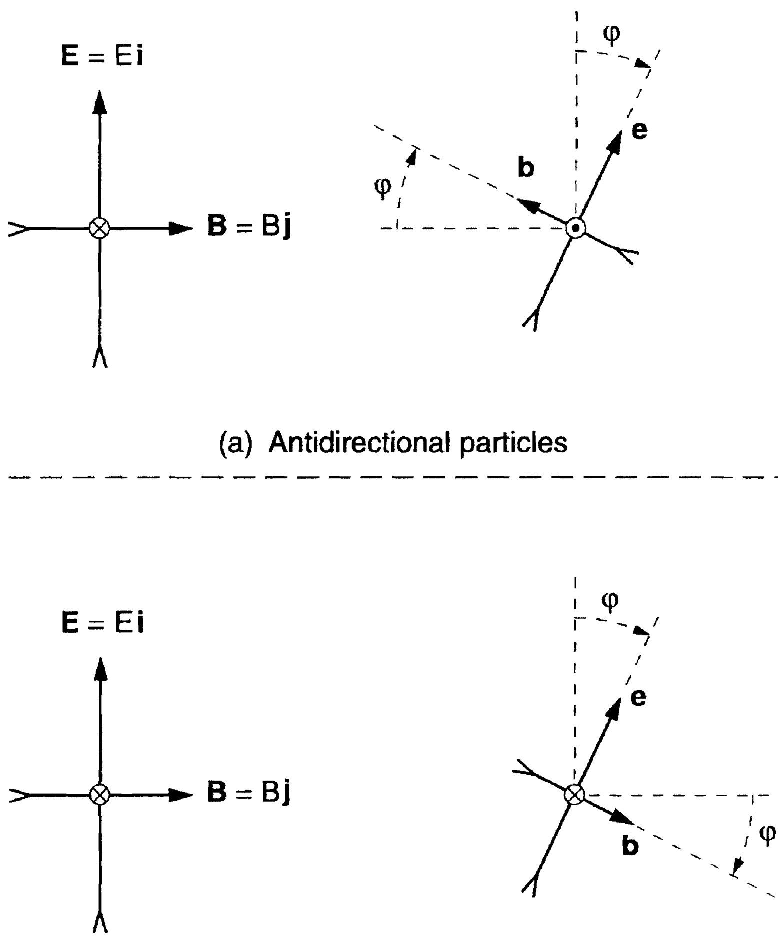
We conclude this Section by remarks on certain forbidden and allowed interactions between two particles. Writing $b = 0$ or $e = 0$ in Eqs. (18), (19) and (20), one finds that their solution requires an absurdity—namely that $\sin \varphi = \cos \varphi = 0$. Thus, fusion of a stationary nonphoton with a moving particle is forbidden. Similar reasoning leads one to conclude that the fusion of a stationary "electric" nonphoton with a stationary "magnetic" nonphoton is forbidden. It may also be noted that reversing the direction of only one of the two formalism vectors changes a particle's vector momentum; and, in this sense, is forbidden. Of course, reversing the directions of both of these vectors does not change a particle's mass energy or momentum; and, in this sense, is allowed. Finally, it may be noted that the fusion-fission formalism of Eqs. (13) and (14) in no way closes the door on allowed elastic collisions between two particles. We exploit such allowed events to explain Newtonian gravity in Section VI.



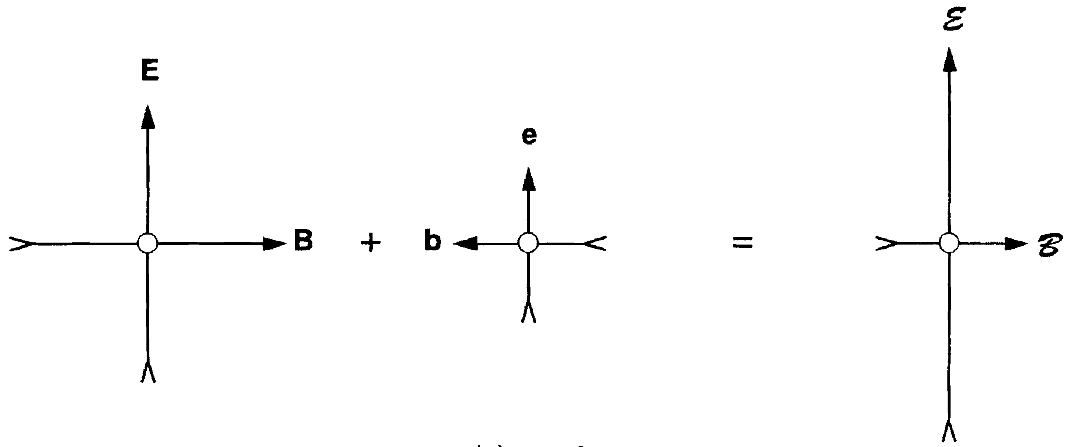
(a) Antidirectional particles

(b) Codirectional particles

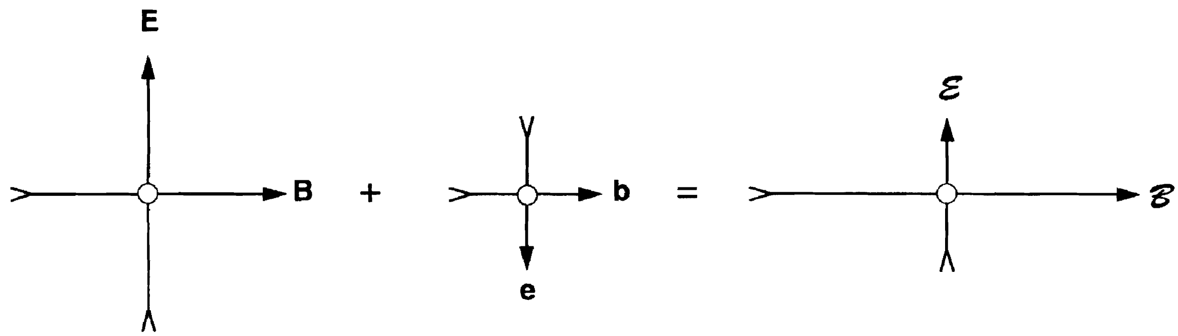
Safonov, universe, fig1-4

Note: Positive φ measured clockwise from indicated reference lines.

Figure 2. Vector Orientations of Collinear Neutral Particles.



(a) $\varphi = 0$

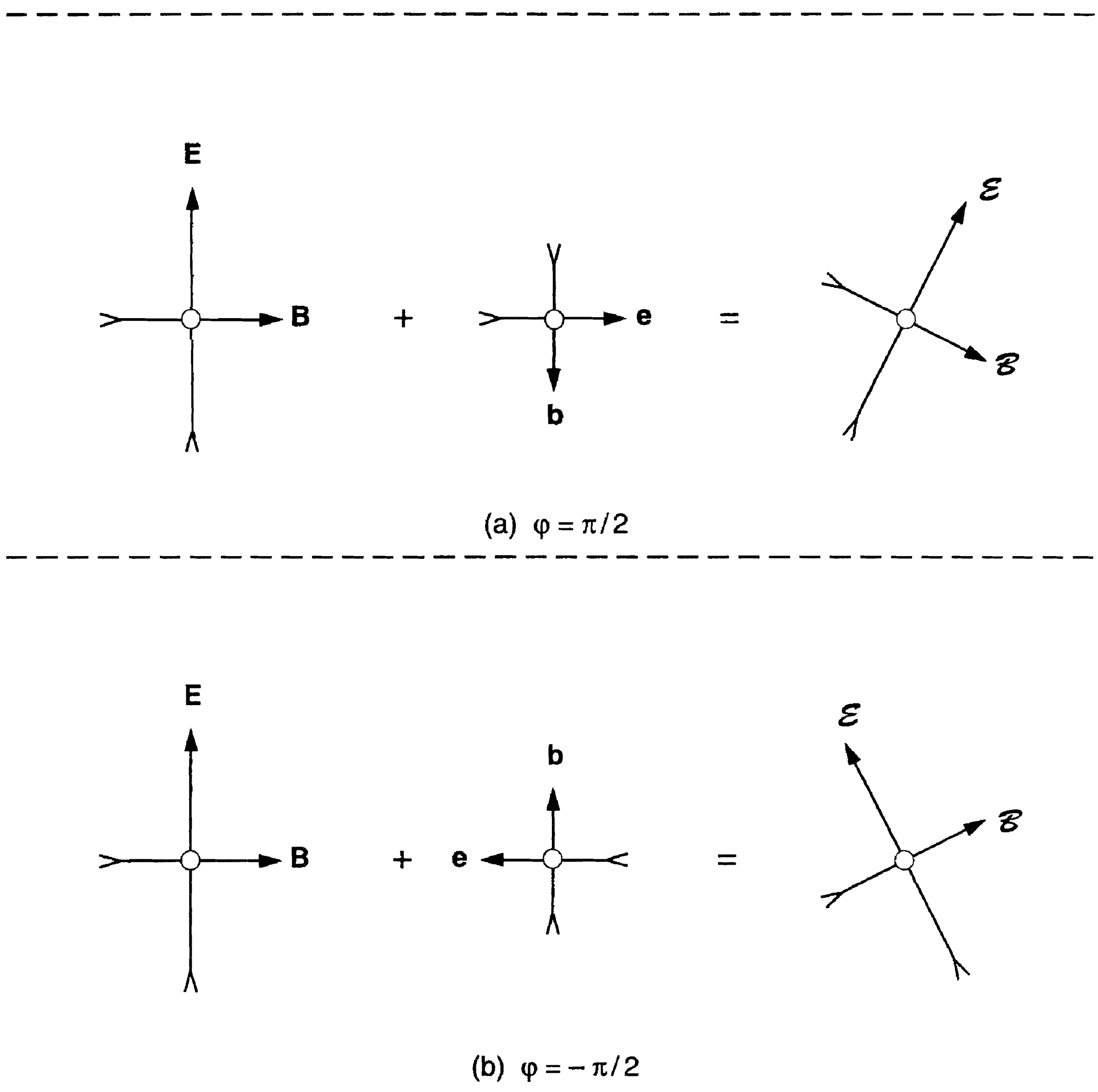


(b) $\varphi = \pi$

Safonov, universe, fig1-4

Note: $E = B = \sqrt{2}$; $e = b = 1/\sqrt{2}$; and, $\mathcal{E}$, $\mathcal{B}$ moves at $\beta = 3/5$.

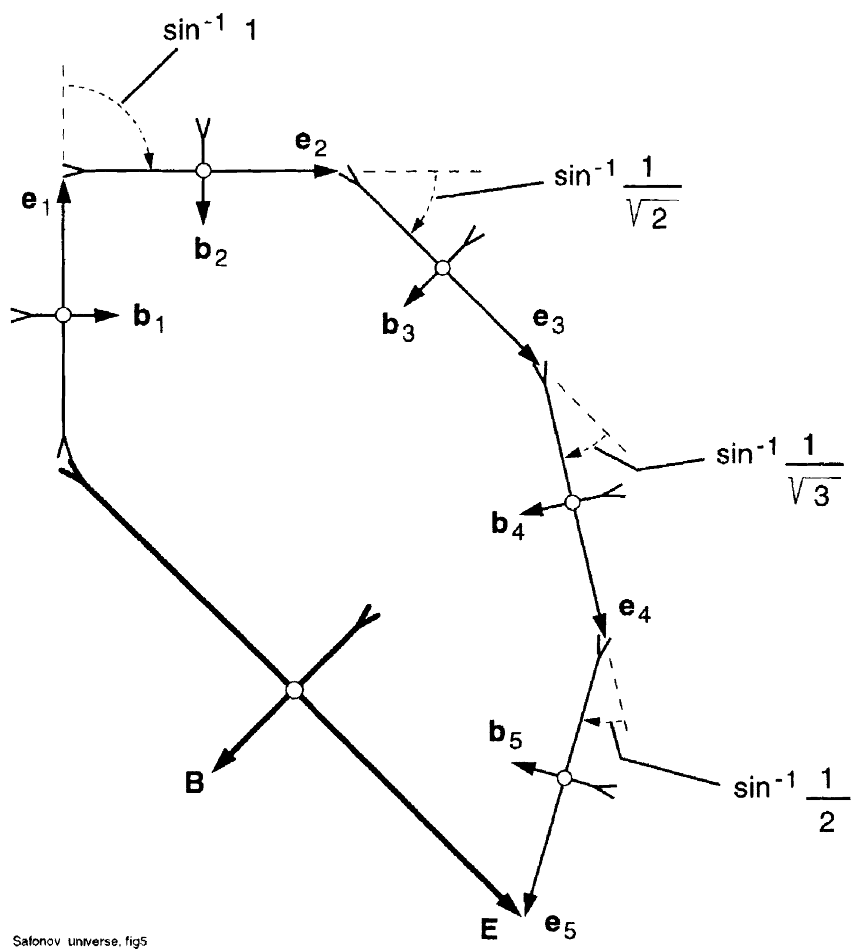
Figure 3. Illustrating Allowed Fusion of Antidirectional Photons.



Safonov, universe, fig1-4

Note: $E/B = e/b = \mathcal{E}/\mathcal{B} = 3/2$; and, all particles move at $\beta = 12/13$.

Figure 4. Illustrating Allowed Fusion of Codirectional Particles.



Notes:

(1) System Parameters

$N = 5$

$\beta = 3/5$

$|\mathbf{e}_i| = 3/\sqrt{10}$

$|\mathbf{b}_i| = 1/\sqrt{10}$

$|\mathbf{E}| = |\Sigma \mathbf{e}_i| = 3/\sqrt{2}$

$|\mathbf{B}| = |\Sigma \mathbf{b}_i| = 1/\sqrt{2}$

(2) Orientation of the $\mathbf{e}_i$ vectors shown in figure assure fusibility of the five $\mathbf{e}_i$, $\mathbf{b}_i$ particles into **E**, **B**

Figure 5. Relative Formalism-Vector Orientations of Five Unit-Energy Particles Fusible into a Single Particle.

IV. PHOTONS AND NONPHOTONS IN EQUILIBRIUM

A. Particle Density Equations

Since photon fusion deaths give birth to nonphotons and nonphoton fission deaths give birth to photons, one is prompted to examine an equilibrium mix of these two basic particle types. The photon component of the mix must obey Bose-Einstein statistics to lead to the Planck photon spectrum, a fact which suggests that we assume the same statistics for both the photon and nonphoton components. A statistical analysis requires one to think in terms of countable energy states of the particles. This requirement is readily met by asserting that particle energies must be integer-multiples of a very small energy quantum, ε. Such an assertion seems plausible since, as demonstrated below, it leads to the correct photon spectrum. The previously defined universe frame has the characteristics of the uniform and isotropic coordinate-momentum phase space underlying conventional determinations of particle densities. Accordingly, we have the conditions in that frame to execute the usual steps leading to particle densities in an equilibrium mix. It will be noted that, to derive the photon and nonphoton densities, we follow the approach used by Bose in arriving at the Planck photon spectrum (Ref. 11).

In units of ε, let m be the mass-energy of the particle that could be formed by the headon fusion of a photon of energy n with one of energy N(≥n). In units of ε/c, denote the particle's momentum by i=(N-n)=(m-2n). Note that n=0 corresponds to photon-particles and that n≠0 to nonphotons. One utilizes all of phase space if one assigns to the subgroup of particles, identified by the integers m and n, that portion of phase space given by

$$\mathcal{V} = 2\,\{V\cdot(4\pi/3)\cdot(\varepsilon/c)^3[(i+\tfrac{1}{2})^3-(1-\delta^i_0)(i-\tfrac{1}{2})^3]\,\};\;\; i \geq 0. \qquad (36)$$

Above, i=(m-2n) is the momentum of a particle in the subgroup; V is the coordinate volume in which the particles are located; and, δ^i_0 is the Kronecker delta. It is necessary to double the bracketed quantity since, in general, the two-vector formalism recognizes two distinct (neutral) particles with the same mass-energy and momentum (Eqs. (7) and (8)). In terms of m and n, Eq. (36) becomes

$$\mathcal{V} = V\cdot 8\pi(\varepsilon/c)^3\,[(m-2n)^2+(2-\delta^m_{2n})\Delta]\;, \qquad (37)$$

where Δ=1/24.

Following Bose, let $g_{m,n}$ represent the number of cells of size h^3= (Planck's constant)^3 per unit of coordinate volume. This number is given by

$$g_{m,n} \equiv \mathcal{V}/Vh^3 = 8\pi(\varepsilon/hc)^3\cdot\,[(m-2n)^2+(2-\delta^m_{2n})\Delta]\,. \qquad (38)$$

On the basis of the assumed Bose-Einstein statistics, one obtains

$$F_{m,n} = (g_{m,n})/(e^{m\varepsilon/kT}-1) = 8\pi(\varepsilon/hc)^3 \cdot [(m-2n)^2+(2-\delta^{m}_{2n})\Delta] /(e^{m\varepsilon/kT}-1) \qquad (39)$$

for the number-density of the particle group identified by a particular pair of m and n integers. Above, k is Boltzmann's constant and T the system temperature as measured by a classical monatomic gas thermometer.

Other particle densities of interest are the mass-energy density,

$$U_{m,n} = \varepsilon m F_{m,n} \,; \qquad (40)$$

the rest-mass energy density,

$$U^{R}_{m,n} = 2\varepsilon\{\sqrt{[n(m-n)]}\}\, F_{m,n}; \qquad (41)$$

and,

$$U^{K}_{m,n} \equiv U_{m,n} - U^{R}_{m,n} = \varepsilon\{m-2\sqrt{[n(m-n)]}\,\}\, F_{m,n} \,, \qquad (42)$$

the "kinetic-energy" density.

B. <u>Photon and Nonphoton Mass-Energy Densities</u>

To derive Planck's photon spectrum, one writes n=0 in Eq. (40), which gives $U_{m,o} = 8\pi\varepsilon(\varepsilon/hc)^3 \cdot m^3\,[1+(2\Delta/m^2)]\,/(e^{m\varepsilon/kT}-1)\,;\ m\geq 1$ (43)

for the energy density of photons of energy mε. Writing dU for $U_{m,o}$; hν=h·(photon frequency) for mε; hdν=[(m+1)ε-mε] for ε; and neglecting $2\Delta/m^2$ relative to unity, one obtains

$$dU/d\nu = 8\pi(h\nu^3/c^3)/(e^{h\nu/kT}-1)\,, \qquad (44)$$

which is the Planck photon spectrum.

----- ----- ----- ----- ----- ----- -----

Figure 6 shows the mass-energy densities of all the m,n-subgroups. Planck's photon curve (n=0) is shown adjoining a surface labeled the "moving nonphoton surface". Closely spaced points on that surface represent the mass-energy densities of the moving nonphotons seen in the universe frame. The surface lies between the photon curve and the stationary nonphoton curve, which indicates the relatively low mass-energy densities of the stationary nonphotons seen in the universe frame. Stationary nonphoton mass-energy densities are given by Eq. (40) written with $2n=m$. And, if $2\leq 2n<m$, that equation gives these densities for the moving nonphotons.

Figure 7 displays particle mass-energy density as a function of m and particle speed, β. The nonphotons in an m,n-subgroup move, relative to the universe frame, at $\beta=(N-n)/(N+n)=(m-2n)/m$. Thus, neglecting $2\Delta/m^2$ relative to unity, the mass-energy density of a nonphoton is β^2 times that of a photon of the same energy. Since m and n are integers, particle speeds do not--rigorously--form a continuum. However, at mass-energies much greater than ε(i.e., not too far below kT), particle speeds are so closely packed as to well approximate the continuum implied by Fig. 7. The mass-energy density of a stationary nonphoton is very small relative to a photon of equal energy, but not zero.

C. Features of the 2.73K System

Summing Eqs. (39) through (42) over the appropriate range of n and m values, one obtains the densities of the photon (n=0), the moving (m>2n) and the stationary (m=2n) nonphoton populations. The results of such summations for a 2.73K mix of photons and nonphotons seen in the universe frame are shown in Table 1. As there noted, the entries are based on the assumption that $\varepsilon/kT \ll 1$.

Provided $\varepsilon/kT \ll 1$, the properties of the photon population are essentially independent of the ε/kT ratio. However, it is seen that the moving nonphoton densities are of order kT/ε larger than those of photons. That is, the moving nonphoton densities are found to dwarf those of photons by order kT/ε; but, the average mass-energies of the two particle types are found to be comparable. As noted at the bottom of Table1, the average kinetic energy of the great-majority particles (the moving nonphotons) is found to equal, approximately, the classical average of "hard sphere" atoms. The stationary nonphoton densities are found to be of order (ε/kT) or $(\varepsilon/kT)^2$ smaller than the photon densities.

As seen in the table, the moving nonphotons have an average rest mass energy equal to $3\pi/16$ times the average of their mass-energies. Writing $P = \alpha m$ in Eq. (10), one finds that a nonphoton with these average properties would move at speed αc, where α satisfies $\sqrt{(1-\alpha^2)} = 3\pi/16$. That is, the average 2.73K space nonphoton moves at a relativistic speed of $\alpha \cong 0.81$ as noted in the fifth row of Table 1. The table also shows that the average mass energy of moving nonphotons is $(I_4/I_3)(kT)$ which equals $\sim 0.9\times 10^{-3}$eV for T = 2.73K.

A knowledge of the speed and mass-energy of the average moving nonphoton permits one to relate the energies of the two photons that would--via fusion--form such a nonphoton to the central space parameter, kT/ε. By use of Eqs. (23) and (25) and Table 1 entries, we find that the average 2.73K space nonphoton would be formed by fusion of photons with energies $A\varepsilon$ and $a\varepsilon$, where

$$A = (1/2)(1+\alpha) \cdot (I_4/I_3) \cdot (kT/\varepsilon) \tag{45}$$

and

$$a = (1/2)(1-\alpha) \cdot (I_4/I_3) \cdot (kT/\varepsilon). \tag{46}$$

Other useful properties of these nonphotons that depend on the central parameter are their number density

$$D = n \cdot (kT/\varepsilon); \tag{47}$$

their mass-energy density

$$\rho_o c^2 = n(kT) \cdot (I_4/I_3) \cdot (kT/\varepsilon); \tag{48}$$

and their directional flux

$$\Phi = (\alpha c n/4\pi) \cdot (kT/\varepsilon); \tag{49}$$

where $$n \equiv (4\pi^5/45) \cdot (kT/hc)^3 \cong 184\text{cm}^{-3}. \tag{50}$$

The pressure felt by a perfectly reflecting surface of nonphotons is given by

$$p = (\alpha^2/3)\, n\mu c^2 (kT/\varepsilon), \tag{51}$$

where $$\mu c^2 = (A{+}a)\varepsilon = (I_4/I_3)\, kT \cong 0.9\times10^{-3}\text{ eV} \tag{52}$$

denotes the average mass-energy of $T = 2.73$K space nonphotons.

The above, which may be obtained from Table 1 information, will be used for our later demonstration that gravitational forces might be understood in terms of nonphoton elastic impacts on ponderable matter constituents.

To compare the shapes of the energy spectra of the three particle-groups considered in Table 1, we have prepared Fig. 8. There, the maximum mass-energy density of each particle-group is normalized to unity. One group consists of all moving nonphotons that have the same mass-energy, but do not necessarily move at the same speed. The stationary nonphotons and the photons constitute the other two groups cited in the figure..

D. Connections between Event-Probability Parameters

In his "A/B coefficient" approach to Planck's law, Einstein used the label "molecule" when referring to objects that absorb and emit photons (Ref 12). He assumed two types of emission: photon-induced and spontaneous emission; and, he assumed this latter process to be unaffected by the photon environment. It is noted that the nonphoton object, introduced here, plays the same role--on a cosmological scale--as Einstein's undefined molecule object. That is, the loss of photons via absorption by a molecule corresponds to the loss via photon-photon headon fusion--the event that creates a nonphoton. And, the emission of photons by molecules corresponds to the production of photons via nonphoton fission into antidirectional photon pairs.

Following Einstein, we also assume two types of events yield photons: namely, photon-induced fission of nonphotons and spontaneous fission of nonphotons. Adopting Einstein's assumption that the spontaneous process is unaffected by the photon environment, it follows that connections must exist between event-probability parameters associated with the fusion of photons and the fission of nonphotons. A derivation of the relationships between such parameters is presented in Appendix C. The necessary connections are found to be

$$1/\tau_{m,n} = 8\pi c(\varepsilon/hc)^3 \cdot \{[n^2+2\Delta]\cdot[m-n)^2+2\Delta] / [(m-2n)^2+(2-\delta^{2n}_{m})\Delta]\} \cdot \mu_{n,(m-n)}, \quad (53)$$

$$\mu_{n,m} = \{ [(m-n)^2+2\Delta] / [(m-2n)^2+(2-\delta^{2n}_{m})\Delta] \} \cdot \mu_{n,(m-n)} \quad (54)$$

and

$$\mu_{(m-n),m} = \{[n^2+2\Delta] / [(m-2n)^2+(2-\delta^{2n}_{m})\Delta]\} \cdot \mu_{n,(m-n)} . \quad (55)$$

Above, the quantity $\mu_{n,(m--n)}$ represents the microscopic cross section for the fusion of a photon of energy n with one of energy $(m-n)\geq n\geq 1$ to form a nonphoton of mass-energy m. That is, the per-unit-volume birthrate of such nonphotons is given by $F_{n,o} x c \mu_{n,(m-n)} x F_{(m-n),o}$, where the F-quantities are given by Eq. (39). The quantity $1/\tau_{m,n}$ is the probability per unit time that such a nonphoton will spontaneously fission into a pair of antidirectional photons. The quantities $\mu_{n,m}$ and $\mu_{(m-n),m}$ are the microscopic cross sections for the fission of such nonphotons that are induced by photons of energy n and (m-n), respectively. That is, the rate of fissions of such nonphotons in a unit volume that are induced by photons of energy n is given by $F_{n,o} x c \mu_{n,m} x F_{m,n}$ and the rate induced by photons of energy (m-n) is given by $F_{(m-n),o} x c \mu_{(m-n),m} x F_{m,n}$.

Since $\Delta=1/24$ and since $(m-n)\geq n\geq 1$ for nonphotons, one may--without appreciable error--neglect the 2Δ terms in the numerators of the above three equations. Except for the stationary (m=2n) nonphotons, one may also neglect the Δ terms in the denominators.

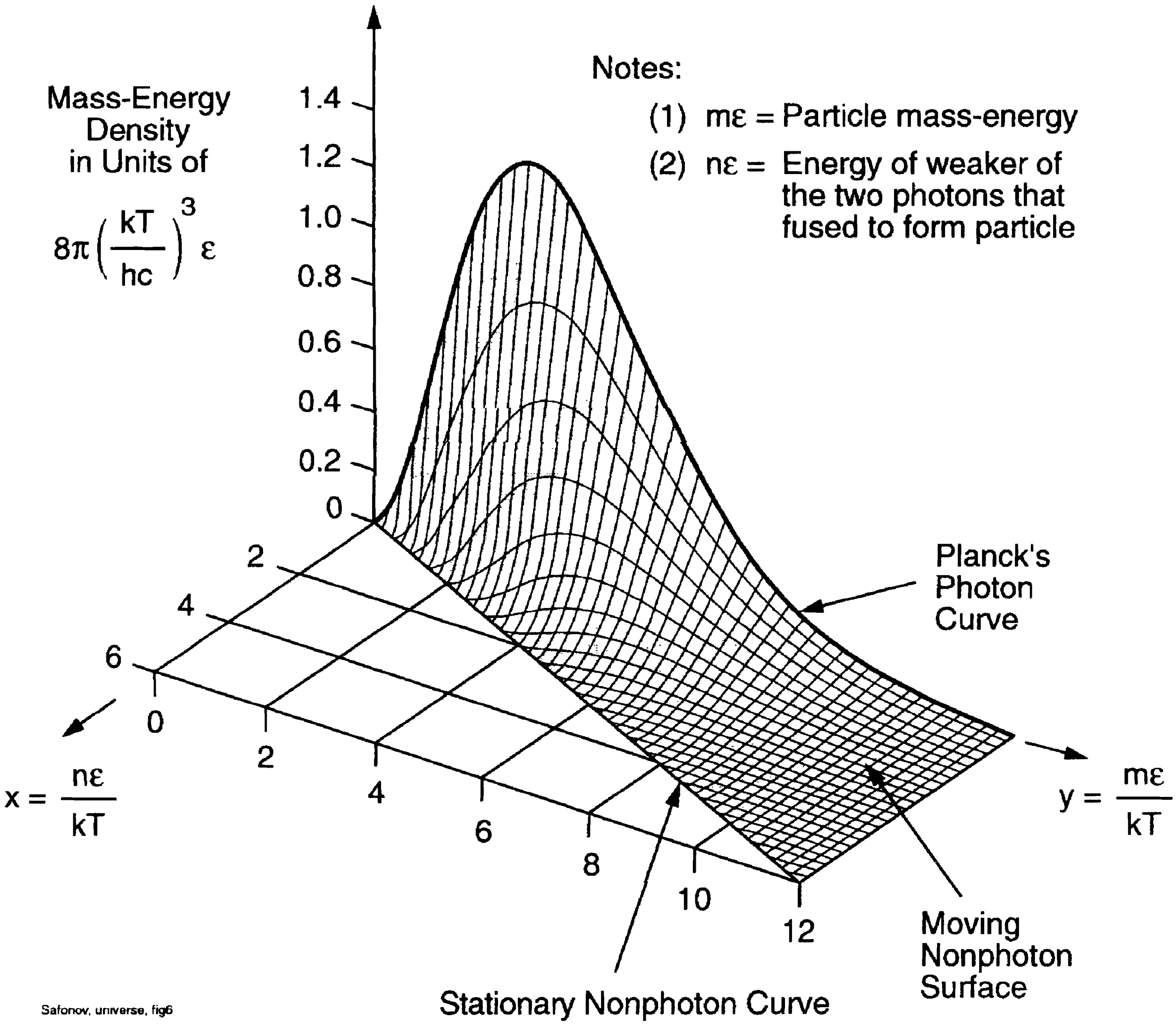


Figure 6. Particle Mass-Energy Densities: Surface Representation.

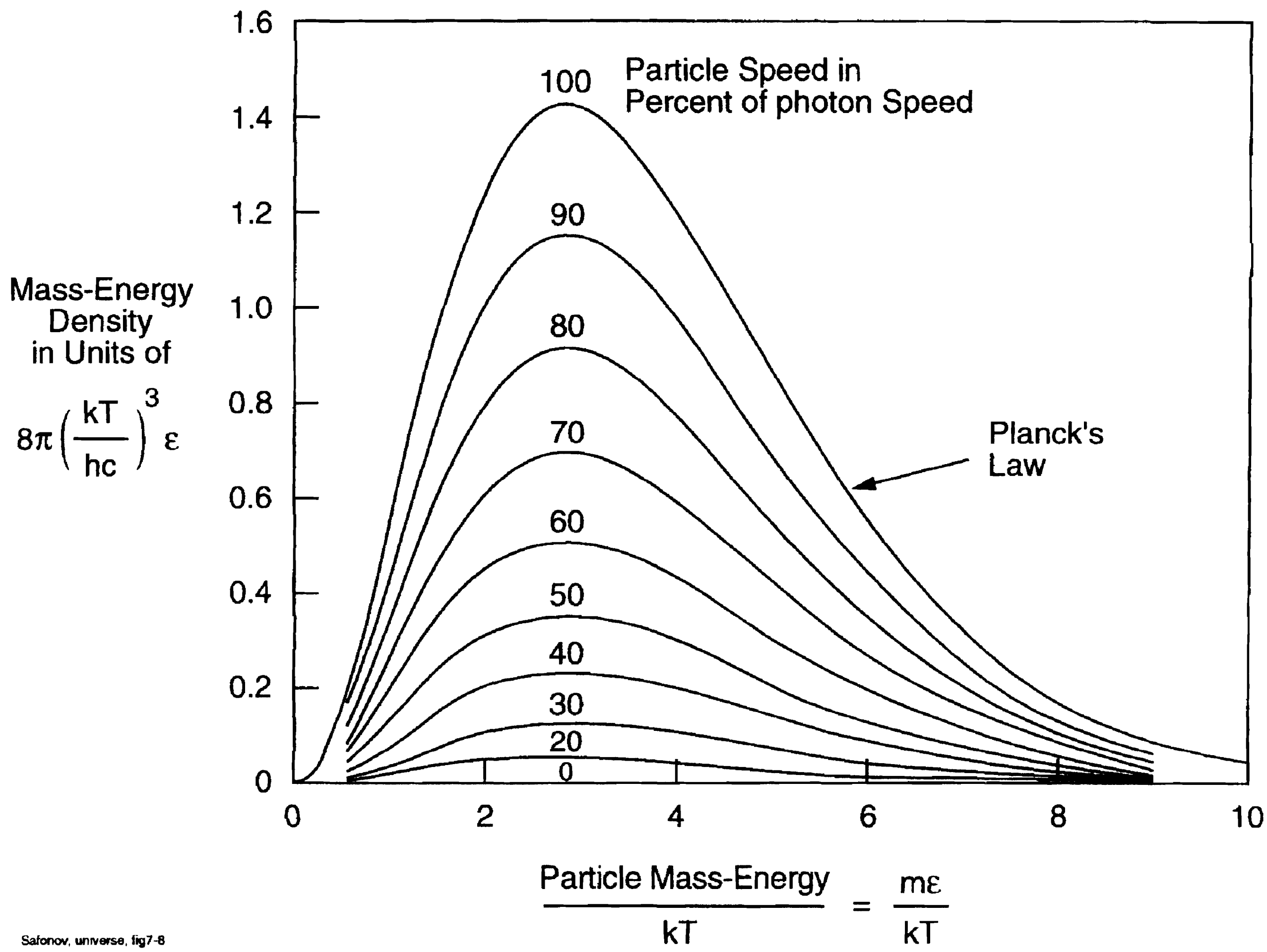


Figure 7. Particle Mass-Energy Densities as Functions of Particle Mass-Energy and Speed.

Table 1. Features of Particles in 2.73°K Model Universe

Particle Property	Type of Particles: Photons (n = 0) (m ≥ 1)	Nonphotons (n ≠ 0): Moving (m > 2n ≥ 2)	Nonphotons (n ≠ 0): Stationary (m = 2n ≥ 2)
Number Density (cm^{-3})	$F = I_2[8\pi(kT/hc)^3] =$ 4.09×10^2	$(I_3/6I_2)F\cdot(kT/\varepsilon) =$ $1.84\times10^2(kT/\varepsilon)$	$(\Delta/2I_2)F\cdot(\varepsilon/kT)^2 \ln(kT/\varepsilon) =$ $3.54\ [(\varepsilon/kT)^2 \ln(kT/\varepsilon)]$
Mass Energy Density ($eV\cdot cm^{-3}$)	$U = I_3[8\pi(kT/hc)^3\cdot(kT)] =$ 0.260	$(I_4/6I_3)U\cdot(kT/\varepsilon) =$ $0.165\ (kT/\varepsilon)$	$(\Delta I_1/2I_3)U\cdot(\varepsilon/kT)^2 =$ $1.37\times10^{-3}(\varepsilon/kT)^2$
Rest-Mass Energy Fraction	0	$3\pi/16 = 0.590$	1
Kinetic Energy Fraction	1	$(1-3\pi/16) = 0.410$	0
Speed ratio: Particle Average / Photon	1	$[1-(3\pi/16)^2]^{1/2} \cong 0.81$	0
Average of Particle Mass Energies (eV)	$U/F = (I_3/I_2)(kT) =$ $2.70(kT) =$ 6.36×10^{-4}	$(I_4/I_3)(kT) =$ $3.83(kT) =$ 8.95×10^{-4}	$I_1(kT)/\ln(kT/\varepsilon) =$ $1.64(kT)/\ln(kT/\varepsilon) =$ $3.87\times10^{-4}[1/\ln(kT/\varepsilon)]$

Safonov, universe tables

Notes:

(1) $\Delta = 1/24$

(2) For T = 2.73°K, $(kT) = 2.35\times10^{-4}$eV

(3) $(\varepsilon/kT) << 1$

(4) $I_i \equiv \int_0^\infty [x^i/(e^x-1)]dx$

$I_1 = \pi^2/6 \cong 1.64493$

$I_2 \cong 2.40410$

$I_3 = \pi^4/15 \cong 6.49392$

$I_4 \cong 24.88627$

$I_5 = 8\pi^6/63 \cong 122.0808$

(5) Average kinetic energy of moving nonphotons is ~ 0.410x3.83kT = 1.57kT. Compare with 1.5kT = classical average of "hard sphere" atoms.

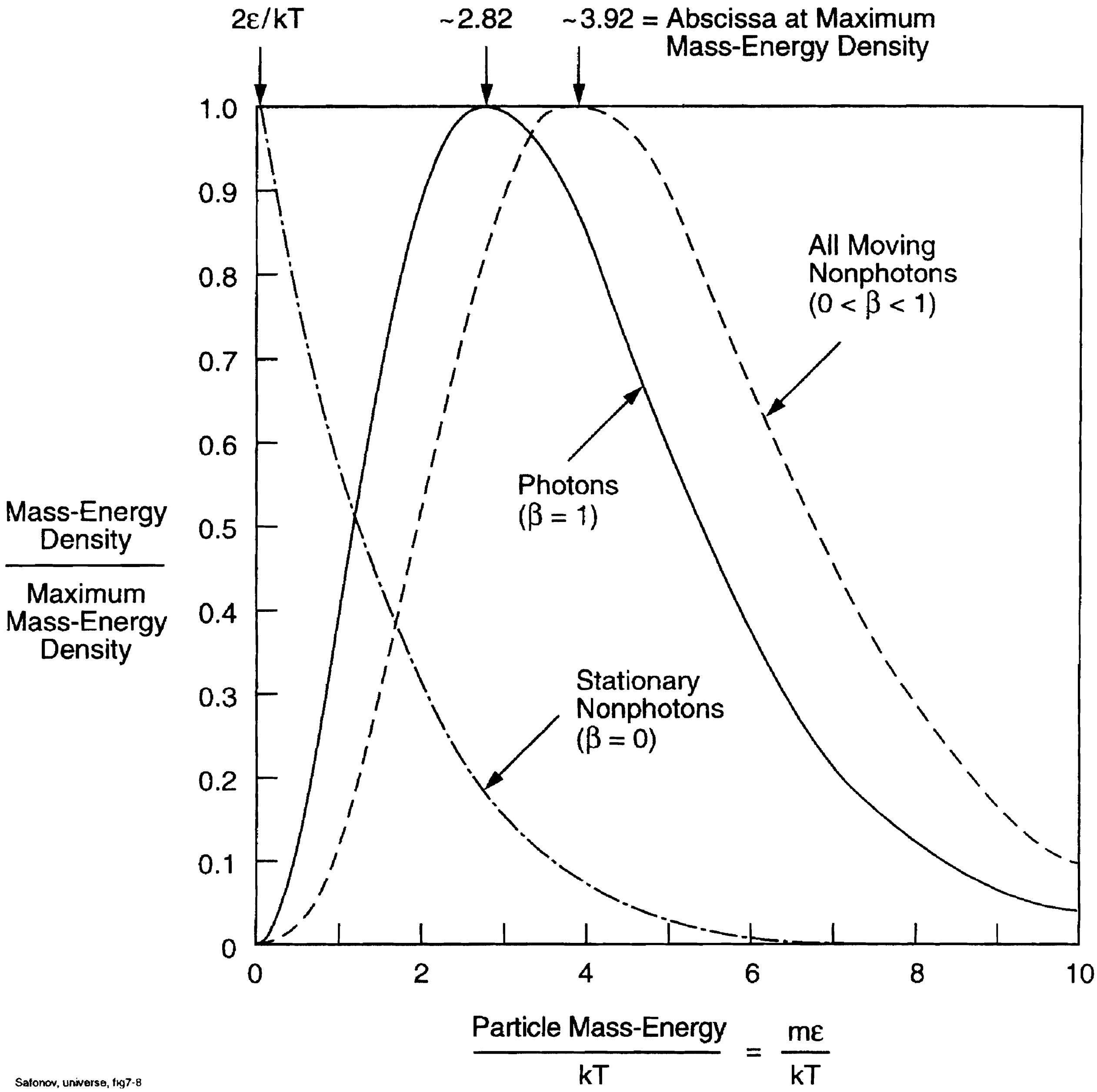


Figure 8. Normalized Mass-Energy Spectra of Photons and Nonphotons.

V. PHOTON REDSHIFT IN A STATIC UNIVERSE

The observed redshift of light that has traveled cosmological-scale distances is generally attributed to special relativistic Doppler effects. Being based on special relativistic point-like particle dynamics, the photon-nonphoton universe model, of course, also recognizes this type of redshift. However, we do not require that the observable universe be expanding to explain redshift as does a "big bang" scenario. Here, we show that similar redshift could occur in a photon-nonphoton universe that is not only infinite but also static when viewed on the largest cosmological scale.

It has been noted that the photon of energy $m\varepsilon$, where m is an integer, may be represented by an ordered assembly of m photons, each of energy ε (i.e., photon quanta). This special feature--together with the fact that rotations of a quantum's defining (formalism) vectors about its line of motion does not affect its energy and momentum; and, that quanta pairs may fuse headon to form a stationary nonphoton--underlies an explanation of redshift in the static universe model. Basically, as a photon emitted from a source travels to a detector--both source and detector being stationary in the universe frame--the quanta of the source photon are progressively lost via headon fusion with quanta of the 2.73K microwave background photons.

We refer to the quanta of photons from the source as "source quanta" and the quanta of 2.73K space radiation as "space quanta". The number-density of space quanta is U/ε, where U is the total energy-density of space photons. By use of the information in Table 1, we have

$$U/\varepsilon = (8\pi^5/15)(kT/hc)^3(kT/\varepsilon) = (0.260/\varepsilon)\ \mathrm{cm}^{-3} \tag{56}$$

for the number-density of space quanta. Here, T=2.73K and ε is in eV.

On the average over time, a fraction f of the space quanta are assumed to be moving opposite to the direction traveled by source quanta and to have their electric vectors codirectional or antidirectional to that of any source quantum. Thus, $f\cdot U/\varepsilon$ represents the number-density of space quanta that are assumed to be properly oriented for fusion with a source quantum. Now, assume that fusion will occur if the parallel lines traveled by a source quantum and a space quantum are separated by a distance of $\sqrt{(\sigma/\pi)}$, or less. The probability per unit length of travel by a source quantum that it will fuse with a space quantum is then given by

$$(1/\Lambda) = f\cdot(U/\varepsilon)\cdot\sigma = \mu_{1,1}\cdot(U/\varepsilon)\,. \tag{57}$$

Above, $\mu_{1,1}\equiv f\sigma$ plays the role of a microscopic cross section for the "headon" quantum fusion events under consideration; and, Λ^{-1} is the corresponding macroscopic cross section. By use of the U/ε expression of Eq. (56), the macroscopic cross section expression reads

$$(1/\Lambda) = (8\pi^5/15)\,(kT/hc)^3\,(kT/\varepsilon)\cdot\mu_{1,1}\,. \tag{58}$$

Let $m_o\varepsilon$ represent the energy of the emitted source photon and $m\varepsilon$ its energy after traveling a distance r. Since

$$dm = -m\cdot dr/\Lambda\,, \tag{59}$$

we have

$$m = m_o e^{-r/\Lambda}\,. \tag{60}$$

The above exponential attenuation of source-photon energy assures a finite energy-density of such photons in a spacially-infinite universe which is uniformly populated by sources. And, since $m_o/m = \lambda/\lambda_o$ (λ represents photon wavelength), it follows that observations of r and λ/λ_o should yield the constant Λ-value given by

$$\Lambda = r/\ln(\lambda/\lambda_o) \tag{61}$$

if the static universe model is to be in accord with nature.

The redshift, z, incurred by source photons in traveling the distance r is then given by

$$z \equiv (\lambda-\lambda_o)/\lambda_o = m_o/m-1 = e^{r/\Lambda}-1; \tag{62}$$

or, by

$$z \cong r/\Lambda\,;\ r \ll \Lambda. \tag{63}$$

This latter "near-in" approximation of the model's redshift equation conforms with Hubble's observations which led to his law; namely,

$$z \cong (H/c) \cdot r, \qquad (64)$$

where H is Hubble's constant. Observations yield a nominal value of the Hubble time, H^{-1}, equal to about 10^{10} years. This suggests a Λ-value of $c \cdot H^{-1} \cong 10^{10}$ light years ($\sim 10^{28}$ cm).

With a Λ-value in hand, we are able to obtain a value of the microscopic cross section, $\mu_{1,1}$, in terms of the model's energy quantum, ε. Via Eq. (58), one obtains

$$\mu_{1,1} = (15/8\pi^5) \cdot (1/\Lambda) \cdot (hc/kT)^3 \cdot (\varepsilon/kT). \qquad (65)$$

In Figure 9, we display the redshift versus distance curves defined by Eq. (62) and its "near-in" approximation, Eq. (63), which conforms with Hubble's law, Eq. (64). If the special relativity Doppler equation is used to compute an implied recessional velocity of a photon's emitter frame relative to that of the frame of the photon's detector, the implied recessional velocities would be as shown in Figure (10). That velocity would have the magnitude α (in units of c) and be related to the redshift z according to

$$z + 1 = [(1+\alpha) / (1-\alpha)]^{1/2}, \qquad (66)$$

or, equivalently, by

$$\alpha = [(2+z) / (2+2z+z^2)] \cdot z. \qquad (67)$$

For small z-values, α would approximately equal z; and, per Hubble's law of Eq. (64), the above implied recessional speeds would be proportional to r. That is, under these conditions, the recessional speeds would correspond to those between points of an object that was expanding uniformly. Hence, for sources "near-in" to detectors, the implied recessional velocities would correspond to those of a uniformly expanding universe.

The static photon-nonphoton model yields significantly larger redshifts for "far-out" sources than does the extended linear model of Hubble's law. This difference may offer an explanation for the large redshifts recently observed from very distant sources. If such observational data is used to compute a recessional speed via the Doppler equation, the results might be interpreted as an acceleration of the rate of expansion of a universe that might actually be static.

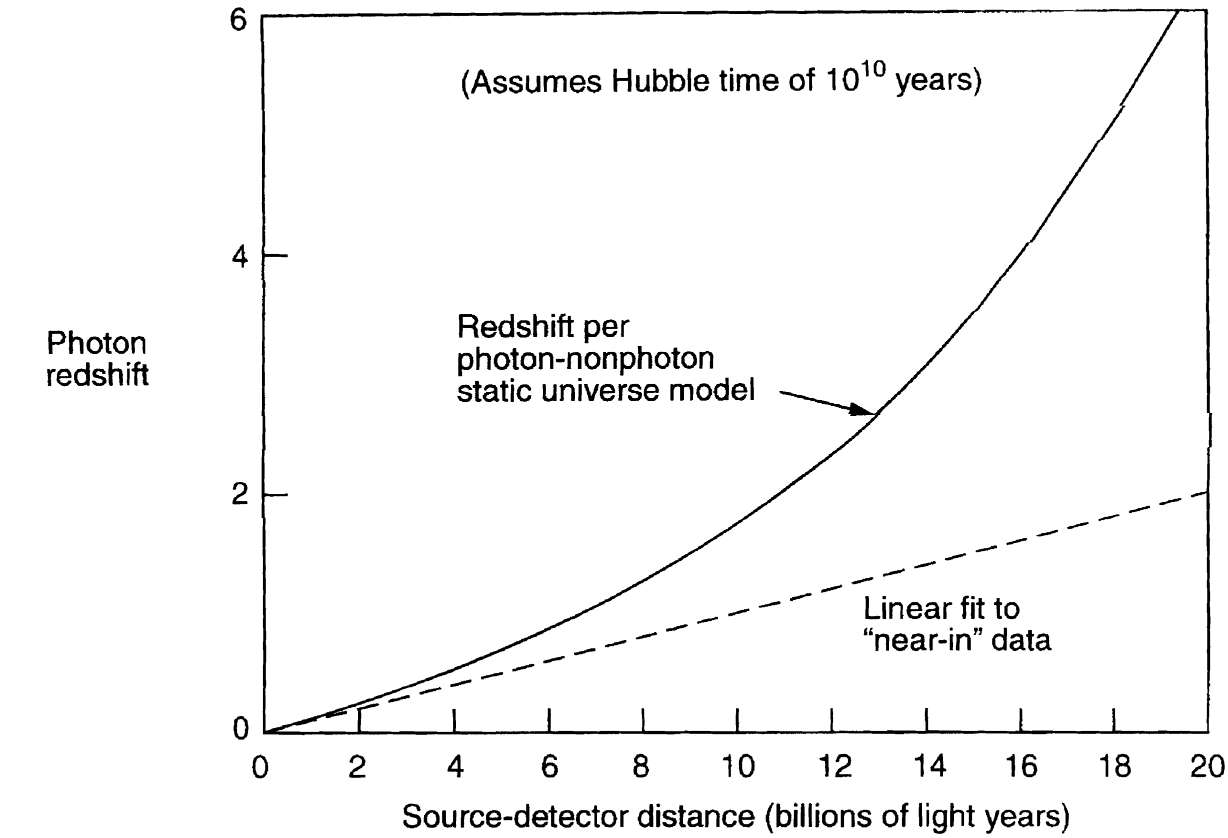


Figure 9. Photon Redshift Curves.

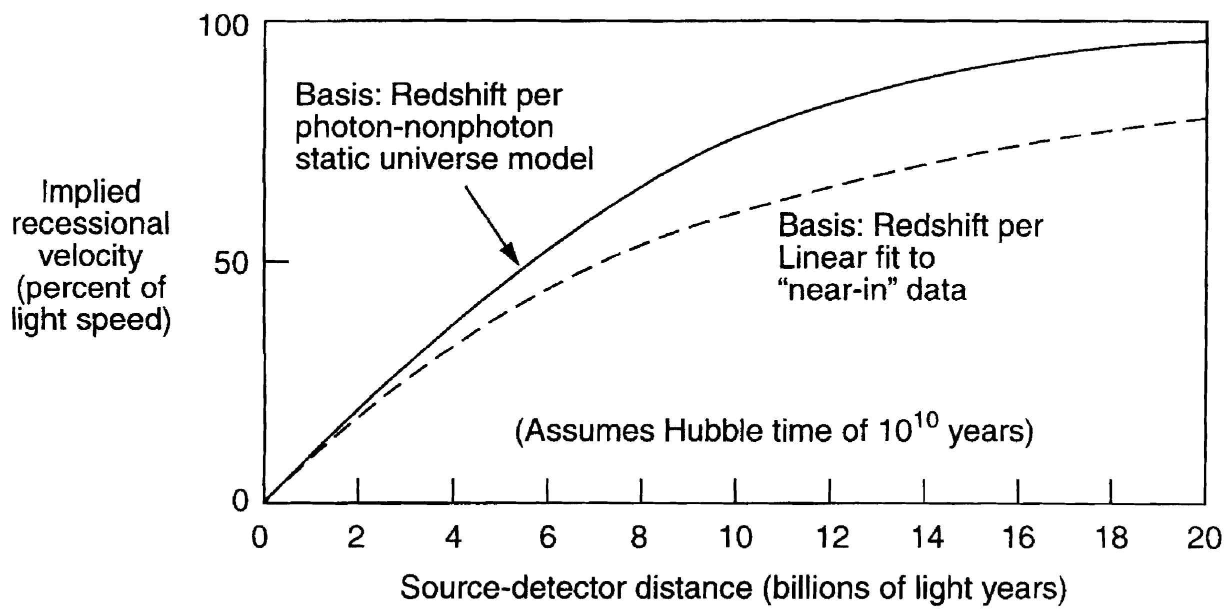


Figure 10. Implied Doppler Recessional Velocities.

Salonov. universe. fig9-10

VI. NONPHOTON GRAVITY

To develop expressions for the particle densities in an equilibrium mix of photons and nonphotons, it was not necessary to examine elastic collisions between the ethereal nonphotons and other particles, either photons or other nonphotons. We visualized an infinite universe where nonphotons are born from the fusion of two photons, each with an energy in the universe frame that equals an integer times a tiny quantum of energy, ε. A photon of energy N fuses with one of energy n($\leq$N) to form a nonphoton, here identified by those two integer numbers as (N,n). Upon spontaneous or photon-induced fission, each nonphoton may later return to the universe the same pair of photons that fused to form it. The model disallowed the fusion of a nonphoton with either a photon or an antidirectional nonphoton. However, elastic encounters between such particle pairs were not disallowed. And, such encounters between nonphotons and photon-like particles are now examined as a possible source of the gravitational forces felt by weighable (ponderable) bodies.

The average moving nonphoton will be used to represent the moving nonphoton community seen in the universe frame. Equations (45) through (52) define several of the properties of the average moving nonphoton. Such a nonphoton will be denoted by (A,a), where A and a are the quantities defined by Eqs. (45) and (46). The basic constituents of ponderable matter are assumed to move at the speed of light and are denoted by (B,0). "Fundamental particles" such as electrons, protons or neutrons, seen at rest in the universe frame, will be modeled by communities of (B,0) "photonics" that move in circular orbits. Such photonic-ring models are developed in Appendix D.

A. (A,a)–(B,0) Elastic Collisions: Definition and Momentum Change

The events to be examined involve the meeting of a nonphoton, (A,a), with a (B,0) photonic. It is to be understood that particle mass-energy, momentum and mass are, respectively, in units of ε, ε/c and ε/c^2, where c is the speed of light. To qualify as an elastic encounter, each particle must at all times be the same entity. That is, if the particle was a nonphoton before the collision it will be the same nonphoton after the collision; and, thereby, be able to return to the universe the same photons that had fused to form it. And, the (B,0) photonic maintains the energy B as it emerges from the collision. This definition of an elastic event assures that the two-particle system's mass energy is conserved, always maintaining the value (A+a+B). Also, the magnitude of each particle's momentum remains unchanged, being (A-a) and B for (A,a) and (B,O), respectively. And, of course, the rest-mass of (A,a) remains at $2\sqrt{(Aa)}$ and that of the photonic,(B,O) is zero throughout the collision event. Only the directions moved by each particle may be altered by their elastic encounter; and, such alterations must conform with the conservation of the two-particle system's vector momentum.

The system's precollision, triangular, momentum-vector diagram is shown in Figure 11. There, ψ represents the angle between the directions moved by the two particles and **P**, the system's vector momentum. In terms of the lengths, (A-a) and B of the individual-particle momentum-vectors, the length of **P** is given by

$$P = [(A-a)^2 + B^2 + 2(A-a)B \cos \psi]^{1/2} \qquad (68)$$

Imagine the precollision triangle to be rotated about **P** out of the plane of the paper by the angle ζ. For arbitrary ζ the orientations of the individual-particle momenta in the rotated figure then represent the directions of the outgoing particles'momenta compatible with the conservation of system momentum. As the triangle is rotated, the point 0 of Figure 11 generates the circle of radius p shown in Figure 12. That radius is given by

$$p(\psi) = [(A-a)B (\sin \psi)]/P \qquad (69)$$

The vector 00′ (Fig. 12) represents the change in momentum experienced by (A,a) if the post-collision plane makes the angle ζ with the precollision plane; and, 0′0 is the change experienced by (B,O). The magnitude of these equal and opposite changes is

$$00' = 2p \sin(\zeta/2) \tag{70}$$

If all ζ-values are equally probable, the average change in each particle's momentum is representable by a vector in the plane of the precollision triangle (Fig. 11). The vector, representing such an average is normal to **P** and its length is given by

$$\int_0^{2\pi} [2p \sin(\zeta/2)] \cdot [\sin(\zeta/2)]\,(d\zeta/2\pi) = p(\psi), \tag{71}$$

where $p(\psi)$ is defined by Eq. (69).

B. <u>Force on Targets of (B,O) Particles under Bombardment by a Beam of (A,a) Nonphotons:</u>

Consider a flat thin target of thickness t and area S. The target contains isotropically-moving and uniformly distributed (B,O) particles. A mono-directional beam of (A,a) nonphotons flows into the target normal to its surface of area S. Let I denote the "current-density" of beam particles (i.e., the rate that beam particles cross a unit area normal to the beam's direction of flow). Let D denote the total number-density of the (B,O) particles in the target and D/2 the density subject to first-hits by (A,a)'s. Our objective is to determine the force felt by the community of target particles (in a unit volume of target) as a result of first hits by the nonphotons of the beam.

The incremental collision rate, associated with (A,a) hits on those (B,O) particles moving in directions $d\psi$ about ψ (see Fig.11), is given by $I \cdot S \cdot \sigma(\psi) \cdot (D/2) \cdot t \cdot (1/2)\ (\sin\psi)\ d\psi$. Here, $\sigma(\psi)$ is the microscopic cross section of (A,a)-(B,O) elastic collisions. To obtain the net force felt by all the (B,O) particles in a unit volume of target, one multiplies by $(\varepsilon/c) \cdot p \cdot \sin\theta$; divides by $S \cdot t$; and, integrates over all ψ values. Since,

$$\sin\theta = B\ (\sin\psi)/P \tag{72}$$

one obtains

$$F = (1/2) \cdot (\varepsilon/c) \cdot I \cdot (D/2) \cdot (A-a) \int_{0}^{\pi} \sigma\ (\psi)[B/P]^2\ \sin^3\psi d\psi. \tag{73}$$

for the force felt by the (B,O) photonics in a unit volume of the target particles

A single photonic would move in a straight line through the isotropic nonphoton flux in the "zero gravity" regions of the universe frame if we take $\sigma(\psi) = \sigma \cdot \sin\psi$, where σ is a constant. For this particular form of $\sigma(\psi)$, Eq. (73) may be expressed as

$$F = (1/4)\cdot(\varepsilon/c)\cdot I\cdot D(A\text{-}a)\cdot\sigma\cdot f(\gamma). \tag{74}$$

Above, γ is defined by

$$\gamma \equiv B/(A\text{-}a), \tag{75}$$

which is recognized as the ratio of (B,O)'s momentum magnitude to that of (A,a). The function, $f(\gamma)$, is given by

$$f(\gamma) = \gamma^2 \int_0^{\pi} \sin^4\psi\,[1+\gamma^2+2\gamma\cos\psi]^{-1}\,d\psi. \tag{76}$$

Special features of this function are

$$f(\gamma) \cong (3\pi/8)\gamma^2;\ \gamma^2 \ll 1, \tag{77}$$

$$f(1) = \pi/4\ , \tag{78}$$

and

$$f(\gamma) \cong (3\pi/8);\ \gamma^2 \gg 1\ . \tag{79}$$

C. <u>Space Nonphotons as a Cause of Gravitational Force</u>

Here our objective is to demonstrate that Newtonian gravity could be the result of impacts of 2.73K space nonphotons on the (B,O) photonics of ponderable matter. Our task is to relate the properties of average space nonphotons, (A,a), and of average ponderable matter photonics, (B,O), to parameters which define a photon-nonphoton universe and also conform with Newton's prescription for gravitational forces. A "central parameter" is the very large number, K, defined by

$$K \equiv (kT/\varepsilon), \tag{80}$$

where T = 2.73 Kelvin and ε ($<<kT \cong 2.35\times10^{-4}$ eV) is a tiny quantum of energy. The dependence of nonphoton quantities on K is given by Eqs (45) through (52). As previously noted, the α quantity appearing in those equations is the speed of the average moving nonphoton (as seen in the universe frame) in units of c; its value is given by

$$\alpha = [1 - (3\pi/16)^2]^{1/2} \cong 0.81. \qquad (81)$$

To develop the dependence of ponderable matter quantities on K and other parameters compatible with Newtonian gravitational forces, we will refer to Figure 13. There, two spheres of weighable matter are shown embedded in the infinite sea of the (A,a) nonphotons of 2.73 Kelvin space. The number density of (A,a) is everywhere—both inside and outside the spheres—equal to D(A,a). Also, each sphere contains the (B,0) particles that make up its ponderable matter. The number density of (B,0) in the sphere of mass M and radius R is

$$D_M(B,0) = [Mc^2/B\varepsilon] \cdot 3/4\pi R^3; \qquad (82)$$

and, that of the sphere of mass m and radius r is

$$D_m(B,0) = [mc^2/B\varepsilon] \cdot 3/4\pi r^3\,. \qquad (83)$$

To derive Newton's law, we require that all bodies—in systems which the law describes with reasonable accuracy—are very thin relative to the mean-free path for (A,a) collisions with (B,O) particles. This means it is sufficient to consider the spheres to be very small relative to the distance, L, between their centers*. Under these conditions, the solid angles subtended by one sphere at points of the other are well approximated by

$$\Omega_M = \pi r^2/L^2 \tag{84}$$

and

$$\Omega_m = \pi R^2/L^2. \tag{85}$$

These solid angles are shown in Figure 13.

In the absence of one sphere, it is evident that the other would feel no net force due to the uniform bombardment from all directions by (A,a) nonphotons. Only spherically-symmetric compressive forces would arise throughout the interior of an isolated sphere. With two spheres of ponderable material present, each is shielded, to some degree, by the other. This results in a net force felt by each that pushes it toward the other. Let us first derive the magnitude of the net force felt by M due to the presence of m.

If the mean free path in space, $\wedge$, for (A,a)-on-(A,a) collisions is large relative to L—as we must assume—then the essentially monodirectional current density of (A,a) that flows within Ω_M into M would—in the absence

*That is, if Newton's law applies to incremental portions of large bodies, it will also apply to the large bodies themselves, provided the latter present very thin targets to space nonphotons.

of m—be $\Phi\Omega_M$ where Φ is given by Eq. (49). In the presence of m, this current density is reduced by scattering of some (A,a)'s by collisions with one half of the (B,O)'s in m. The fraction scattered in the thin-target m is $[(m/2)c^2/B\varepsilon] \cdot \bar{\sigma}/(\pi r^2)$, where $\bar{\sigma}$ is a microscopic cross-section for such scattering events. For $\sigma(\psi) = \sigma \cdot \sin\psi$ and assuming a body's photonics move isotropically, we have $\bar{\sigma} = \pi\sigma/4$. Under these conditions, there flows into M from the left an excess current density of

$$I_M = (\pi/8)\,[mc^2\sigma/B\varepsilon] \cdot [1/\pi r^2] \cdot \Phi\Omega_M. \qquad (86)$$

According to Eq. (74), the force felt by the (B,O) particles in a unit volume of M due to its exposure to I_M is

$$F_M = (1/4)(\varepsilon/c) \cdot I_M \cdot [D_M(B,O)] \cdot (A\text{-}a) \cdot \sigma \cdot f(\gamma), \qquad (87)$$

where γ and $f(\gamma)$ are defined by Eqs. (75) and (76). Multiplying by M's volume, one finds the force on M due to the presence of m is

$$\mathcal{F}_M = \mathcal{G}_M \cdot mM/L^2, \qquad (88)$$

where $$\mathcal{G}_M = (\alpha^2/128) \cdot (nc^4/kT) \cdot \sigma^2 \cdot [(A+a)f(\gamma)/B^2] \cdot K^2. \qquad (89)$$

Repeating the above sequence to derive the force on m due to the presence of M, one finds this force to be

$$\mathcal{F}_m = \mathcal{G}_m \cdot mM/L^2, \qquad (90)$$

where $$\mathcal{G}_m = \mathcal{G}_M\,. \qquad (91)$$

Hence, the force that pushes M toward m is equal and opposite that which pushes m toward M. And, the magnitude of this force would equal that predicted by Newton's law if $\mathcal{G}_M$ equaled Newton's $G = 6.66 \times 10^{-8}$ dynes $\cdot$ $cm^2 \cdot (gram)^{-2}$. In this case, the three identifying numbers of (A,a) and (B,O); the parameter K; and, the cross-section σ are constrained so as to satisfy

$$B^2/[(A+a)f(\gamma)] = (\alpha^2/128)\,(nc^4/GkT) \cdot \sigma^2 \cdot K^2. \qquad (92)$$

We denote the average of $\sigma \cdot \sin\psi$ by $\bar{\sigma}$. The cross section $\bar{\sigma}$ may be expressed in terms of λ, the average mass of weighable thin-ring-type matter per unit area penetrated by a nonphoton prior to its first collision with a photonic, and the photonic's mass energy, $B\varepsilon$, as

$$\bar{\sigma} = 2B\varepsilon/c^2\lambda = (\pi/4)\sigma. \qquad (93)$$

And, according to Eq. (52),

$$(A+a) = (\mu c^2/\varepsilon). \qquad (94)$$

By use of Eqs. (93) and (94), the constraint of Eq. (92) may be expressed as

$$K \cdot f(\gamma) \cdot \lambda^{-2} = (2\pi^2/\alpha^2) \cdot (G/n\mu c^2) \qquad (95)$$

In what follows, we seek specific values of λ, K and γ, the three quantities needed to complete our demonstration that gravitational forces might be understood in terms of elastic collisions between 2.73K space nonphotons with the photonic constituents of weighable matter.

D. The λ, K and γ Parameters

We start by specifying the value of the parameter denoted by λ. A nonphoton must travel through an average of λ grams/cm^2 of weighable matter to experience its first elastic colllision with a photonic constituent of such matter. Nonphoton Newtonian gravity is a first collision concept. The effects of second collisions are assumed to cause the uncertainty in the measured values of G, Newton's gravitational constant. That uncertainty is taken to be about one part in 10^5*. The probability for a second collision in the sun would be about 10^{-5} if $\lambda = 10^{16}$ grams/cm^2, the value of λ taken here. And, of course, such a large λ-value satisfies a basic requirement of the nonphoton gravity concept—namely that solar system bodies present "thin targets" to nonphotons.

In addition to λ, we seek the values of two dimensionless parameters. One is K, the "central" parameter of a photon-nonphoton universe defined by Eq. (80). The second parameter is γ, which represents the ratio of the magnitude of the average photonic's momentum to that of the average nonphoton, (Eq. (75)).

*According to "Physics News in 2000", a supplement to APS News, an uncertainty of 0.0014% was reported by Jens H. Gundlach of the University of Washington at the APS meeting in Long Beach.

To estimate the value of K, we utilize the fact that almost all of the mass of solar-system bodies is that of their protons and neutrons. These nucleons will be represented by a photonic-ring model (see Appendix D). Nucleon rest mass, M. is $\sim 1.67 \times 10^{-24}$ grams and the ring model's radius, R, is $\sim 1.05 \times 10^{-14}$ cm. The ring thickness is denoted by 2r, where r<<R.

We take the surface area of a nucleon ring to equal $N\sigma$. Here N is the number of photonics making up a nucleon and σ represents $\sigma(\psi)$ for $\psi = \pi/2$. (Recall that we took $\sigma(\psi)$ to equal $\sigma \cdot \sin\psi$). Thus, we have

$$4\pi^2 Rr = N\sigma. \tag{96}$$

Let δ represent $B\varepsilon$, the average energy of a photonic as seen in the universe frame. In terms of δ, N is given by

$$N = Mc^2/\delta. \tag{97}$$

And, according to Eq. (93), σ may be expressed in terms of δ by

$$\sigma = (8/\pi) \cdot (\delta/c^2\lambda). \tag{98}$$

Substituting these N and σ expressions into Eq. (96), and solving for the nucleon ring's half thickness, one obtains

$$r = 2 \cdot (\pi^3\lambda)^{-1} \cdot (M/R) \cong 1.026 \times 10^{-27} \text{ cm}. \tag{99}$$

A ring's circulating photonics will experience dynamic equilibrium if its surface feels a pressure p that satisfies.

$$pV=Mc^2 \tag{100}$$

where $$V = 2\pi^2 Rr^2 \tag{101}$$

is the volume of the ring, (see Appendix G). By use of Eq. (99), we find the pressure required for dynamic equlibrium is

$$p = (\pi^4/8)\lambda^2 c^2 \cdot (R/M) \cong 0.69 \times 10^{64} \text{ dynes/cm}^2. \tag{102}$$

In pursuit of a K-value, we assume that the nucleon ring's surface perfectly reflects the nonphotons that hit it. Since $r<<R$ an essentially isotropic flux of nonphotons bombards the ring's exterior. The resulting pressure felt by the exterior surface due to such bombardment is given by Eq. (51), which—in terms of K—is

$$p = (\alpha^2/3)\, n\mu c^2 K. \tag{103}$$

For dynamic equilibrium, the above p-value must equal that given by Eq. (102). Equating the two values and solving for the central parameter K, one obtains

$$K = (3\pi^4/8\alpha^2) \cdot (\lambda^2/n\mu) \cdot (R/M) \cong 1.21 \times 10^{77}. \tag{104}$$

Via Eq. (80), one finds the value of the tiny energy quantum to be

$$\varepsilon = (kT/K) \cong 1.94 \times 10^{-81} \text{ eV}. \tag{105}$$

To determine the value of γ, the last of the trio of desired parameters, we first find $f(\gamma)$ by substituting the λ and K values into Eq. (95). This yields

$$f(\gamma) = (16/3\pi^2) \cdot (G/c^2) \cdot (M/R) \cong 6.36 \times 10^{-39}. \qquad (106)$$

For such a small value of f(γ), Eq. (77) tells us that—to a high degree of accuracy—$f(\gamma) \cong (3\pi/8) \cdot \gamma^2$. Thus, we find

$$\gamma = (8/3\pi) \cdot [2GM/\pi c^2 R]^{1/2} = 7.34 \times 10^{-20}. \qquad (107)$$

Summarizing, we took $\lambda \cong 10^{16}$ grams/cm^2 on the basis of the uncertainty in G and the requirement that solar-system bodies present thin targets to nonphotons. Next, we modeled nucleons by photonic rings. By asserting that the pressure resulting from particle bombardment of a ring's exterior be equal and proper for dynamic equilibrium of the ring's circulating photonics, a value of the pressure was obtained. Equating this pressure to that felt by a perfectly reflecting surface of nonphotons, we found the central parameter of the photon-nonphoton universe must be $K \cong 1.21 \times 10^{77}$. With the values of λ and K in hand, we found $\gamma \cong 7.34 \times 10^{-20}$ via the λ-K-γ connection required for nonphoton gravity to equal Newtonian gravity.

It may be noted that the value of λ and the λ-K-γ connection of Eq.(95) derived from considerations of phenomena on the scale of the solar system. In contrast, the K-λ connection of Eq. (104) derived from consideration of phenomena on the scale of a nucleon. By combining the findings of the considerations on these vastly different scales, a first set of specific values of λ, K and γ have been obtained and may now be utilized to define important features of the modeled photon-nonphoton universe.

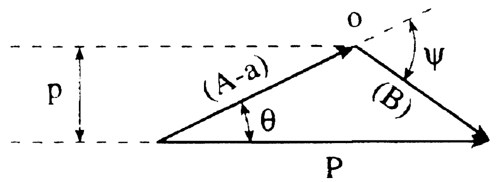


Figure 11. System momentum triangle.

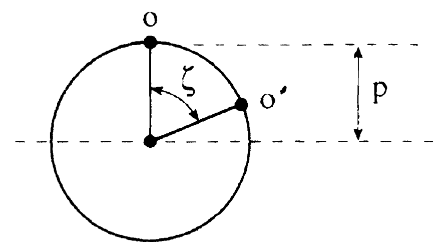


Figure 12. Circle generated by point o by rotating system momentum triangle about P.

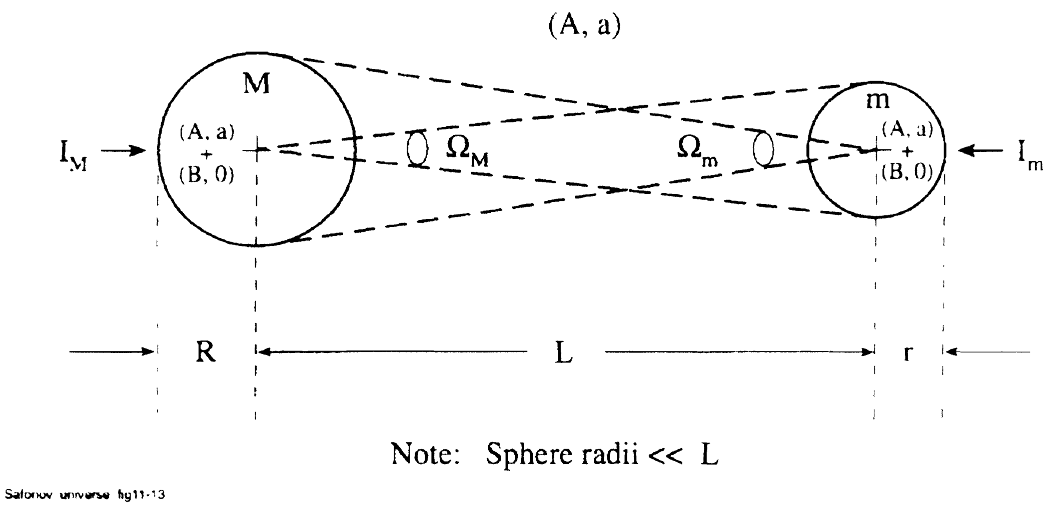


Figure 13. Spheres of ponderable mass M and m embedded in a sea of space nonphotons.

VII. EMERGING FEATURES OF THE MODELED UNIVERSE

On the basis of the specific values of the trio of parameters now in hand, namely,

$$\lambda = 10^{16}\ \text{grams/cm}^2,$$

$$K = 1.21 \times 10^{77}$$

and

$$\gamma = 7.34 \times 10^{-20},$$

we are able to determine the implied properties of a variety of particles (nonphotons, photonics, electrons, protons and neutrons) in the modeled photon-nonphoton universe.

A. <u>Nonphoton-Related Quantities</u>

In the universe frame, the average moving nonphoton would be seen to be formed by the headon fusion of a photon consisting of A ε-quanta with one of a (<A) quanta, where

$$A = (1/2)(1+\alpha) \cdot (\mu c^2/kT) \cdot K \cong 4.175 \times 10^{77} \tag{108}$$

and

$$a = (1/2)(1-\alpha) \cdot (\mu c^2/kT) \cdot K \cong 0.445 \times 10^{77}\,. \tag{109}$$

The values of ε, α and $\mu c^2$are given by Eqs.(105), (81) and (52) respectively; and, T = 2.73 Kelvin. The number density of these nonphotons is

$$D = n{\cdot}K \cong 2.228 \times 10^{79} \cdot \text{cm}^{-3}; \tag{110}$$

their inertial-mass density is

$$\rho_o = n\mu \cdot K \cong 3.562 \times 10^{43} \text{ grams} \cdot \text{cm}^{-3}; \qquad (111)$$

and, their directional flux is

$$\Phi = (\alpha/4\pi)\, cn \cdot K \cong 4.30 \times 10^{88} \text{cm}^{-2} \cdot \text{sec}^{-1} \cdot \text{steradian}^{-1}. \qquad (112)$$

If nonphotons are perfectly reflected by a surface, the surface feels the pressure

$$p = (\alpha^2/3) \cdot n\mu c^2 \cdot K \cong 0.690 \times 10^{64} \text{ dynes} \cdot \text{cm}^{-2}. \qquad (113)$$

The definition and the value of the quantity n is given by Eq. (50)

B. Photonic-Related Quantities

The momentum magnitude of the average photonic is δ/c and that of the average moving nonphoton is $\alpha\mu c$. By definition, γ is the ratio of the former to the latter. Hence, the average photonic's energy is given by

$$\delta = \alpha\mu c^2 \cdot \gamma \cong 5.34 \times 10^{-23} \text{ eV}. \qquad (114)$$

That δ is considerably smaller than the average energy of either the microwave background photons or the moving nonphotons of 2.73K space is evident from inspection of Table 1 entries. The number of ε-quanta making up the average photonic constituent of weighable matter is

$$B = \delta/\varepsilon = (\alpha\mu c^2/kT) \cdot K \cdot \gamma \cong 2.745 \times 10^{58}. \qquad (115)$$

In constructing photonic-ring models of the electron, proton and neutron (Appendix D), each photonic was assumed to be without electric charge or to carry a charge of $+\zeta$ or $-\zeta$. The value of ζ is proportional to δ according to

$$\zeta = \sqrt{2} \cdot (\delta/mc^2) \cdot e = \sqrt{2} \cdot (\alpha\mu/m) \cdot e \cdot \gamma \cong 7.10 \times 10^{-38} \text{ esu}, \qquad (116)$$

where m represents the electron's rest mass and e the magnitude of its charge (see Eq. (D9) of Appendix D).

C. Microscopic Cross Sections

The microscopic cross section for the elastic collision of an average nonphoton with an average photonic of weighable matter is

$$\bar{\sigma} = 2(\delta/c^2\lambda) = 2(\alpha\mu) \cdot \lambda^{-1} \cdot \gamma \cong 9.50 \times 10^{-72} \text{ cm}^2. \qquad (117)$$

Table 1 shows the average energy of a microwave background photon is $\sim 6.36 \times 10^{-4}$ eV, which equals $\sim 1.19 \times 10^{19} \times \delta$. If the equivalence of mass and energy and that of inertial and gravitational masses are to hold, the microscopic cross section for an elastic encounter between a nonphoton and a background photon must be $\sim 1.19 \times 10^{19} \times \sigma \cong 1.13 \times 10^{-52}$ cm^2. The number density of background photons is $409/\text{cm}^3$. Thus, the mean-free path for such encounters in free space is $[409 \times 1.13 \times 10^{-52}]^{-1}$ $\cong 2.16 \times 10^{49}$ cm, or about 2.16×10^{31} light years.

The above-cited microscopic cross sections may be compared with μ_{11}, the cross section for ε-quantum fusion that offers an explanation of redshift in a static universe (Section V). Via Eq. (65) and Eq. (50), that "redshift" cross section may be expressed as

$$\mu_{11} = [6n \wedge \cdot K]^{-1} \cong 7.48 \times 10^{-109}\ \text{cm}^2. \qquad (118)$$

Here, $\wedge$ represents the product of c times the Hubble time. The above μ_{11} value assumes a Hubble time of $\sim 10^{10}$ years which yields a $\wedge$ value of $\sim 10^{28}$ cm.

D. <u>Features of Photonic-Ring Models of the Electron, Proton and Neutron</u>

Appendix D describes many—but not all—of the features of photonic-ring models of a trio of particles (the electron, the proton and the neutron). The models were designed to conform with four of each particle's important properties: mass, charge, angular momentum and magnetic moment. Two or three circles, all of radius R, represent the orbits of a model's photonics. The circles' planes are parallel and closely spaced; and, their centers lie on the model's "axis", a line normal to these planes. On one circle, N^+ photonics, each carrying a $+\zeta$ charge, orbit the axis in one direction. On a second circle, N^- photonics, each carrying a $-\zeta$ charge, orbit in the opposite direction. The electron was modeled by only two circles, the N^+ and the N^- circles. A third circle is required to model a proton or a neutron. On the third circle, N^o electrically neutral photonics orbit in the direction that enhances the net angular momentum of the charged photonics.

In Appendix D, it was possible to define R and the relative populations of each photonic type. However, for lack of a value of δ, it was not possible to specify the values of N^+, N^- and N^o for each member of the particle trio. By use of the δ-value developed here, we can now specify $N = Mc^2/\delta$ (the total photonic population). And, with the relative population figures (N^+/N, N^-/N and N^o/N) developed in Appendix D, the individual populations of each photonic type becomes definable.

Table 2 displays the photonic population figures for the three modeled particles. Also shown are r^+, r^- and r^o, the half-thicknesses of N^+, N^- and N^o rings compatible with dynamic equilibrium under the pressure $p = 0.69 \times 10^{64}$ dynes/cm^2, the pressure felt by perfect reflectors of nonphotons. It should be noted that these half-thickness values are obtained by use of Eqs (100) and (101) with $N^+\delta/c^2$, $N^-\delta/c^2$ and $N^o\delta/c^2$ written for M.

Table 2. Features of Photonic-Ring Particle Models.

Model Feature		Particle Modeled		
		Electron	Proton	Neutron
Mass Energy (MeV)		0.511	938.3	939.6
Photonic Populations	All Rings	0.957×10^{28}	1.757×10^{31}	1.7595×10^{31}
	N^{+} ring	0.140×10^{28}	2.224×10^{28}	1.293×10^{28}
	N^{-} ring	0.817×10^{28}	1.548×10^{28}	1.293×10^{28}
	N° ring	0	1.753×10^{31}	1.757×10^{31}
Ring Radius, R (cm)		2.73×10^{-11}	1.053×10^{-14}	1.051×10^{-14}
Ring Half-thickness (cm)	N^{+} ring, r^{+}	1.794×10^{-31}	3.640×10^{-29}	2.784×10^{-29}
	N^{-} ring, r^{-}	4.330×10^{-31}	3.036×10^{-29}	2.784×10^{-29}
	N° ring, r°	0	1.023×10^{-27}	1.026×10^{-27}

Salonov universe table2

VIII. CONCLUDING REMARKS

Let us recall the path followed in bringing into a coarse focus some of the important features of a photon-nonphoton universe. We have assumed all things in the universe are made up of particles whose dynamic properties transform from one inertial frame to another according to the prescriptions of special relativity. To specify a particle's properties, we utilized the two-vector formalism described in Section II. As a consequence of opting to use this particular formalism two basic particle-types presented themselves. In addition to photons, the notion of "nonphotons" emerged.

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In Section III, we considered the formation of one particle by the fusion of two and the converse fission event as such would be seen in a preferred inertial frame. That frame, referred to as the "universe frame", was assumed to be infinite in extent and age. An observer knows his is the universe frame if he sees an isotropic background of microwave photons with a Planckian energy spectrum at a temperature $T \cong 2.73$ Kelvin.

We postulated that a necessary condition for the above fusion-fission events to occur is that likekind formalism vectors be additive in the universe frame. A consequence of this postulate is that photons and nonphotons could coexist symbiotically. That is, two photons could fuse to form a nonphoton which later could fission to return the same two photons to the universe.

In the universe frame, two photons would be seen to move headon toward the fusion scene. Because of the special relativity energy-momentum transformation rules, in other frames the same two photons would--in general--not be seen to move toward a headon meeting. However, a fusion or fission event would, of course, be seen in all frames though details of particle motions would be seen to differ as described in Appendix B*. As noted in that appendix, if particle mass-energy and momentum transform in accord with special relativity, only one frame may be chosen for the satisfaction of our above-stated fusion-fission postulate. And, to construct the photon-nonphoton universe model, the unique and infinite universe frame was chosen to establish rules that govern allowed particle conversion events. In a sense, the preferred frame corresponds to Newton's absolute space with respect to which bodies were regarded to translate or rotate.

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*Equations B-2 and B-3 of Appendix B define a necessaary condition for photon fusion in terms of an arbitrary frame's (experimentally determinable) "$\underline{\alpha}$-signature", where $\underline{\alpha}c$ is the frame's velocity relative to the $\underline{\alpha}=0$ universe frame. Those equations might be regarded as a "law of nature" since they have the same form for all frames. This law simply requires that photons meet headon in the $\underline{\alpha}=0$ universe frame for fusion to occur.

In Section IV, to develop the densities of photons and nonphotons in an equilibrium mix, we assumed particle energies in the universe frame are integer multiples of a tiny energy quantum, ε. We believe some of the reasons for, and the benefits deriving from, such an assumption deserve to be emphasized.

A discrete energy quantum permitted us to think in terms of countable energy states as required for a statistical analysis of equilibrium particle distributions. A discrete, but tiny, ε is sufficient to generate the Planck photon spectrum on the basis of an appropriate (Bose-Einstein) statistics; and, to generalize the Planck photon curve by extending it into a surface (Figure 6) that defines the spectra of the nonphotons in an equilibrium particle mix. A finite ε leads to densities of nonphotons that are very large ($\sim kT/\varepsilon$ times photon densities), but finite (i.e., we have no singularities with a non-zero ε). And, to develop the redshift idea put forward in Section V, it was helpful to regard photons as a very large number of quanta, each with a very small energy ε, that travel as an ordered group.

Also, with a tiny ε-quantum, our model's "central parameter", $K \equiv kT/\varepsilon$, is a very large—but finite—number. Since the mass-energy density of the ethereal nonphotons is proportional to K, a small volume of the photon-nonphoton universe contains the large energy required for a "mini big bang" event. That is, via photon-induced nonphoton fission, one has the makings of a divergent chain reaction that could unleash—from a small volume--the concentrated mass-energy of ethereals in the form of not-so-ethereal photons. Indeed, strongly collimated photon beams may be formed due to the laser-like nature of photon-induced fission of nonphotons.

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Another effect of the high K-value associated with a tiny ε is the large pressure that would be felt by a perfectly reflecting surface of nonphotons. We have estimated this pressure to be sufficient to confine the photon-like constituents (photonics) to the interior of thin, string-like, models of electrons*, protons and neutrons. The models conform with mass, charge, spin and magnetic moment of these particles. (Section VII and Appendix D). And, we believe similar models of Gell-Mann's quarks may also be constructed.

That such ponderable-matter particles may be modeled by thin rings allowed us to explain Newtonian gravity in terms of the elastic collisions

*In his 1916 book (Ref. 20, page 60), Einstein noted that "The general theory of relativity renders it likely that the electrical masses of an electron are held together by gravitational forces." In a photon-nonphoton universe, the same nonphotons that cause gravitational forces also act to confine the electrically charged photonics of an electron within a very small toroidal region. Thus, such a universe is in accord with this particular conjecture by Einstein over eighty years ago.

between nonphotons and the photonic constituents of string-like electrons and nucleons, (Section VI). Newtonian gravity results when bodies present "thin" targets to nonphotons. That is, in thin targets, a nonphoton can experience essentially no more than one collision with a body's photonics. In going to thick targets, each nonphoton may experience multiple collisions with a body's photonics, and the nonphoton Newtonian gravity theory might be extended to conform with the gravity of general relativity.

At this point, it may be of interest to remark on certain motivations for modeling electrons and nucleons by photonics moving in closed orbits. The rationale becomes evident from a reading of the abstract of Appendix E, which is a copy of a 1949 note (Ref. 1). That abstract reads:

The special relativity Doppler equation is applied to a photon describing a closed path. The time average behavior of this photon is notedly similar to that of a mass equal to the photon's energy divided by the square of the velocity of light. In particular, it is noted that light confined within a small space has the gross properties of a particle. The microscopic properties of such confined photons could explain "intrinsic" spin. The conservation of mass and energy for all types of collisions are natural consequences of such an inner structure.

According to the above, when seen in an inertial frame where an electron or a nucleon is at rest, the observer sees photonics moving in circular orbits, the system's mass-energy being that of the community of circulating photonics. A nonphoton seen at rest may be visualized as a system of photonics moving around a circle of a certain radius. As seen by an observer moving at a speed βc in the direction of the normal to the circle's plane, the photonics would move along helices on the cylinder generated by the moving circle. Thus, nonphotons, like electrons and nucleons, may be visualized as a community of photonics moving along paths which look closed to observers in a nonphoton's rest frame. The angle θ between the tangent of the helix along which a photonic of a nonphoton moves and the helix's axis is defined by $\cos \theta = \beta$.

It appears that all particle-types considered in constructing a photon-nonphoton universe model may be considered to be systems of constituents that are seen in all frames to move at the same speed—that of the speed of light. Since a system cannot move faster than its fastest constituent, we may understand why the speed limit for the particles of nature is c, the speed of light. Also, we may note that with the particles made up of zero-rest-mass photonics, one has Wilczek's particles with "mass without mass" as seems to be a current trend of thought (Refs. 16 and 17).

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Questions raised by fairly recent observations may find answers in terms of properties of a photon-nonphoton universe. For example, a possible explanation of why Doppler theory applied to recent redshift observations implies a universe expanding at an accelerating rate is noted in Section V. The alternative explanation is that a higher-than-linear increase in redshift with increasing distance is a natural feature of the static photon-nonphoton universe model. Also, as noted in Appendix F, nonphotons appear to offer an answer to the question: "What causes the gravitational effects currently attributed to some form of dark matter?" In that appendix, we explain how nonphotons might mimic the existence of not only dark matter but also of a repulsive gravitational force. And, of course, potentially reoccurring problems on the conflicts of the age of an expanding universe and the objects therein are avoided, as is the need for an inflationary epoch in the infinitely old and large photon-nonphoton universe (Refs. 18 and 19).

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Three possible experiments to test aspects of the photon-nonphoton universe model come to mind. First, redshift observations should yield a constant when the distance to the photon emitter is divided by ln (λ_d/λ_e). Here, λ_d and λ_e are the wavelengths of the detected and emitted photons, both emitter and detector being at rest in the universe frame. Second, the average nonphoton, bearing news that a strong gravitational event had occurred, should be found to travel at ~81% of photon speed in the universe frame. Third, if nonphoton bombardment of the photonics of the photonic-ring models of electrons and nucleons is a valid representation of their response to a gravitational field, then the weight of a magnet may be found to vary with its orientation relative to the gravitational field.

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We have drawn together a group of studies that led us to an unconventional model of the universe. This document represents a progress report on a continuing construction of the "photon-nonphoton" model. Thus far, we have been able to bring into coarse focus some of the model's features by noting the multiple roles that nonphotons might play in explaining old and new observations. Future studies will attempt to sharpen the focus while exploring other candidate roles of nonphotons.

APPENDIX A

INERTIAL FRAME SIGNATURES

The observations of an essentially uniform microwave background radiation suggest that the universe might be modeled by a preferred inertial frame. Relative to such a "universe frame", observers would see photons uniformly distributed, moving isotropically and having a 2.73K blackbody energy spectrum. Observers in a frame that moves uniformly through the universe may determine their velocity, αc, relative to the preferred frame via observations of an apparently anisotropic background radiation. That is, every frame within the universe has an α-vector signature, $\alpha = 0$ being that of the universe frame. Here, we describe an experimental procedure by which an observer might determine his frame's α-signature.

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We assume the frame-to-frame transformation prescriptions of special relativity for the properties of point-like particles are applicable; and, we treat photons as a special class of such particles. The general particle's speed relative to the frame, denoted by S, equals βc, where c is the speed of light. The inertial mass of the particle is represented by $m\varepsilon/c^2$, where ε is a tiny unit of energy. The particle's momentum magnitude is represented by $P\varepsilon/c$. By the definition of momentum, $P = \beta m$. The particle's vector momentum—in units of ε/c—is given by

$$\underline{P} = P\,\{\cos\psi\,\underline{i} + \sin\psi\,[\cos\zeta\,\underline{j} + \sin\zeta\,\underline{k}]\}. \tag{A1}$$

Here, $\underline{i}$, $\underline{j}$ and $\underline{k}$ represent unit vectors in the directions of the axes of a cartesian coordinate system in the S-frame. The angle between $\underline{P}$ and $\underline{i}$ is ψ; and, that between the plane of $\underline{P}$ and $\underline{i}$ and the plane of $\underline{i}$ and $\underline{j}$ is ζ.

Relative to S, a second frame, denoted by S′, is assumed to move at the velocity of $\alpha c\underline{i}$. In S′, observers see the above particle to move at the speed $\beta'c$, to have an inertial mass of $m'\varepsilon/c^2$ and a momentum magnitude of $P'\varepsilon/c$. Again, by definition, $P' = \beta'm'$. Taking the unit vectors in S′ to be codirectional with those in S, the particle's vector momentum—in units of ε/c—is given by

$$\underline{P}' = P'\,\{\cos\psi'\underline{i} + \sin\psi'\,[\cos\zeta'\underline{j} + \sin\zeta'\,\underline{k}]\}. \tag{A2}$$

As viewed in S′, the angle between $\underline{P}'$ and $\underline{i}$ is ψ' and that between the plane of $\underline{P}'$ and $\underline{i}$ and the plane of $\underline{i}$ and $\underline{j}$ is ζ'.

According to special relativity,

$$m' = [(1 - \alpha\beta\cos\psi)/\sqrt{1-\alpha^2}]\,m; \tag{A3}$$

and

$$\underline{P}' = \{[(\beta\cos\psi - \alpha)/\sqrt{1-\alpha^2}]\,\underline{i} + \beta\sin\psi\,[\cos\zeta\,\underline{j} + \sin\zeta\,\underline{k}]\}m. \tag{A4}$$

A feature of Eqs. (A3) and (A4) is that—in all S′ frames—m' and P' satisfy

$$(m')^2 - (P')^2 = m_o^2, \tag{A5}$$

where m_o is a constant. Since $P' = 0$ in the particular S′-frame where the particle is seen at rest, $m_o\varepsilon/c^2$ represents the rest mass of a particle capable of rest. According to these equations, a particle seen to move at the speed of light in S (i.e., a $\beta = 1$ particle) has $m' = P'$ in all S′ frames. That is, photons have $m_o = 0$ and are seen to move in all frames at light-speed according to the special relativity prescriptions of Eqs. (A3) and (A4).

Since $m^2 - P^2 = (1 - \beta^2)\, m^2$, the P' quantity for the general particle may be expressed as

$$P' = [(m')^2 - (1 - \beta^2)\, m^2]^{1/2}, \tag{A6}$$

where m' is given in terms of α and the S-frame quantities β, m and ψ by Eq. (A3).

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We now consider the microwave background photons in S, the $\alpha = 0$ universe frame, and in S′ where $\alpha \neq 0$. The photon of energy $m\varepsilon$ in S will have in the S′-frame the energy $m'\varepsilon$ and momentum magnitude $P'\varepsilon/c$, where

$$m' = P' = [(1 - \alpha \cos\psi)/\sqrt{1 - \alpha^2}\,]\, m. \tag{A7}$$

Since $P' = m'$, Eq. (A2) becomes

$$\underline{P}' = \{\cos\psi'\, \underline{i} + \sin\psi'\, [\cos\zeta'\, \underline{j} + \sin\zeta'\, \underline{k}]\}\, m'. \tag{A8}$$

And, since $\beta = 1$, Eq. (A4) becomes

$$\underline{P}' = \{[(\cos\psi - \alpha)/\sqrt{1 - \alpha^2}\,]\, \underline{i} + \sin\psi\, [\cos\zeta\, \underline{j} + \sin\zeta\, \underline{k}]\}\, m. \tag{A9}$$

Equating the $\underline{i}$ components of the above two expressions for $\underline{P}'$, the interdependence of ψ and ψ' is found to be given by

$$\cos\psi' = (\cos\psi - \alpha)/(1 - \alpha \cos\psi); \tag{A10}$$

or, equivalently, by

$$\cos\psi = (\cos\psi' + \alpha)/(1 + \alpha \cos\psi'). \tag{A11}$$

Since the $\underline{j}$ and $\underline{k}$ components of $\underline{P}'$ given by the two expressions for $\underline{P}'$ must be the same, it follows that $\zeta = \zeta'$ and $m \sin\psi = m' \sin\psi'$; conditions which, of course, also yield the Eq. (A10) and (A11) equations.

Substituting the $\cos\psi$ expression of Eq. (A11) into Eq. (A7), we obtain

$$m' = P' = [(\sqrt{1 - \alpha^2}\,)/(1 + \alpha \cos\psi')]\, m \tag{A12}$$

which will be useful in developing, an experimental scheme to determine the α signature of S′.

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The previously defined universe frame (i.e., the $\underline{\alpha} = 0$ S frame) has the characteristics of the uniform, and isotropic coordinate-momentum phase space underlying conventional derivations of blackbody photon spectra, such as the observed microwave background spectrum. And, a statistical analysis requires one to think in terms of countable energy states of photons. To meet this requirement, we assert the photons are seen in S to have energies equal to integer-multiples of a very small energy quantum, ε. That is, we take m to be integer and let our tiny energy unit represent the energy quantum. This assertion and the assumption that our point-like photon particles obey Bose-Einstein statistics yields the 2.73K Planckian spectrum of the microwave background photons.

Because of the isotrophy seen in S, the fraction of the m-group photons that move within the solid angle

$$\Omega(\psi) = 2\pi(1 - \cos\psi) \qquad \text{(A13)}$$

equals

$$f(\psi) = \Omega(\psi)/4\pi = (1/2)(1 - \cos\psi). \qquad \text{(A14)}$$

Let $f'(\psi')$ equal the fraction of m-group photons seen in S′ to move in directions within the solid angle

$$\Omega'(\psi') = 2\pi(1 - \cos\psi'). \qquad \text{(A15)}$$

If ψ' is related to ψ according to Eq. (A11), $f'(\psi')$ will equal $f(\psi)$. This follows from the fact that the components of a photon's momentum normal to $\underline{\alpha} = \alpha\underline{i}$ are the same in S and S′. Hence, by use of Eqs. (A14) and (A11), we find

$$f'(\psi') = [(1/2)(1 - \cos\psi')] \bullet [(1-\alpha)/(1+\alpha\cos\psi')]. \tag{A16}$$

In S, the "per-steradian fraction" is given by

$$df/d\Omega = 1/4\pi \tag{A17}$$

for $d\Omega$ about any direction ψ. In S′, the per-steradian fraction is the function of direction, ψ', given by

$$df'/d\Omega' = (1/4\pi) \bullet [(1-\alpha^2)/(1+\alpha\cos\psi')^2]. \tag{A18}$$

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The scheme here described for the experimental determination of an inertial frame's α signature envisions measurements of the energy flow rates of the microwave background photons into an instrument. These rates depend on the number density of each m-group of photons. Let F(m) represent the number density of m-group photons seen at any time in S. As seen at any time in S′, this number density would be

$$F'(m) = (1-\alpha^2)^{-1/2} F(m). \tag{A19}$$

That is, the number between two planes normal to $\underline{\alpha} = \alpha\underline{i}$ and separated by a distance L in S would equal the number between these two planes as seen in S′ to be separated by the contracted distance $(1-\alpha^2)^{1/2}$ L in S′. If these planes reflected each photon such that --in S--the angles of reflection equaled those of incidence, this clearly would be true. Under those conditions, the number between the planes would remain constant since none escape. And, if the planes suddenly became transparent, those moving out would be equal to the number moving into the other side of the two-plane region. On average, over time, Eq. (A19) expresses the relationship between the number densities of the m-group photons as seen in S and S′.

To determine the energy flow rates into an instrument, we start by noting that $F'(m) \cdot [df'/d\Omega'] \cdot d\Omega'$ equals the number density of those m-group photons seen in S′ to move in directions within $d\Omega'$ about a line making the angle ψ' with $\underline{\alpha} = \alpha\underline{i}$. The product of c times that incremental number density represents the rate that these m-group photons cross a unit area normal to that line. We will be concerned with the rates that m-group photons flow across unit areas of planes oriented in two special directions. In one case, the plane of interest is normal to $\underline{\alpha}$. In the second case, $\underline{\alpha}$ is parallel to the planes of interest. The energy flow rates, of course, would simply equal the product of $m'\varepsilon$, where m' is given by Eq. (A12), and the above number flow rates.

In the first case, the incremental flow rate of m-group photons across a unit area of plane normal to $\underline{\alpha}$ in the $+\underline{i}$ direction is given by

$$dI'_{\perp}(m) = (\cos\psi')\ c\ F'(m)\,(df'/d\Omega')\,d\Omega'. \qquad \text{(A20)}$$

By use of Eqs. A(18) and (A19), the above may be expressed as

$$dI'_{\perp}(m) = [c\ F(m)(1-\alpha^2)^{1/2}/4\pi] \cdot [(\cos\psi')/(1+\alpha\cos\psi')^2]\,d\Omega'. \qquad \text{(A21)}$$

For those m-group photons that move in directions $d\psi'$ about ψ',

$$d\Omega' = d[2\pi(1-\cos\psi')] = 2\pi\sin\psi' d\psi', \qquad \text{(A22)}$$

the value of $dI'_{\perp}(m)$ is given by

$$dI'_{\perp}(m) = [c\ F(m)\,(1-\alpha^2)^{1/2}/2] \cdot [(\cos\psi'\sin\psi')/(1+\alpha\cos\psi')^2]\,d\psi'. \qquad \text{(A23)}$$

The associated incremental energy flow rate is given by

$$dU'_{\perp}(m) = [c\varepsilon mF(m)\,(1-\alpha^2)/2] \cdot [(\cos\psi'\sin\psi')/(1+\alpha\cos\psi')^3]\,d\psi', \qquad \text{(A24)}$$

which is obtained by use of the m' expression of Eq. (A12). Except for the constant of integration, the integral of Eq. (A24) is

$$U'_{\perp}(m,\psi') = [c\varepsilon mF(m)(1-\alpha^2)/2\alpha^2] \cdot [-(1+\alpha\cos\psi')^{-1} + (1/2)(1+\alpha\cos\psi')^{-2}]. \qquad \text{(A25)}$$

Of interest here are the two quantities given by

$$_{+}U'_{\perp}(m) = [c\varepsilon mF(m)/4] \cdot [(1-\alpha)/(1+\alpha)] \tag{A26}$$

and $$_{-}U'_{\perp}(m) = [c\varepsilon mF(m)/4] \cdot [(1+\alpha)/(1-\alpha)]. \tag{A27}$$

Equations (A26) and (A27) give the rates that the energy of m-group photons are seen in S′ to flow across a unit area of a plane normal to $\underline{\alpha}$ in the $+\underline{\alpha}$ and $-\underline{\alpha}$ directions, respectively.

In the second case, we seek the rates that the energy of m-group photons cross a unit area of a plane to which $\underline{\alpha}$ is parallel. We start by noting that the quantity

$$\sin\psi' \sin\zeta cF'(m)(df'/d\Omega') \sin\psi' \, d\psi' d\zeta$$

represents the rate that m-group photons, moving with directions in $d\zeta$ about ζ and $d\psi'$ about ψ' cross a unit area of the $\underline{i,j}$ plane. Of course, since $\underline{\alpha} = \alpha\underline{i}$, the $\underline{i,j}$ plane of the S′ frame represents a plane to which $\underline{\alpha}$ is parallel. Now, let $dI'_{\parallel}(m)$ represent the integral of the above quantity with respect to ζ over the range 0 to π. By use of Eqs. (A18) and (A19), we have

$$dI'_{\parallel}(m) = [cF(m)(1-\alpha^2)^{1/2}/2\pi] \cdot [(\sin^2\psi')/(1+\alpha\cos\psi')^2] \, d\psi'. \tag{A28}$$

Multiplying by $m'\varepsilon$, we obtain the associated incremental energy flow rate

$$dU'_{\parallel}(m) = [c\varepsilon mF(m)(1-\alpha^2)/2\pi] \cdot [(\sin^2\psi')/(1+\alpha\cos\psi')^3] \, d\psi'. \tag{A29}$$

Except for the constant of integration, the integral of Eq. (A29) is

$$U'_{\parallel}(m,\psi') = [c\varepsilon F(m)(1-\alpha^2)/2\pi] \cdot \Big\{(1-\alpha^2)^{-3/2} \tan^{-1}\big\langle [(1-\alpha)/(1+\alpha)]^{1/2} \tan\psi'/2\big\rangle$$

$$- \sin\psi'[2\alpha(1-\alpha^2)(1+\alpha\cos\psi')]^{-1}$$

$$+ \sin\psi' [2\alpha(1+\alpha\cos\psi')^2]^{-1}\Big\} \tag{A30}$$

Of interest here is the quantity

$$U'_{\parallel}(m) = [c\varepsilon mF(m)/4] \cdot (1-\alpha^2)^{-1/2}, \tag{A31}$$

which represents the rate that the energy of m-group photons is seen in S′ to cross a unit area of any plane to which $\underline{\alpha}$ is parallel from either above or below said plane. As previously noted $\underline{\alpha} = \alpha\underline{i}$, so the $\underline{i}\,\underline{j}$ plane is an example of such a plane. However, the direction of $\underline{j}$ is arbitrary so we are able to say Eq. (A31) gives the value of $U'_{\parallel}(m)$ for any plane to which $\underline{\alpha}$ is parallel.

In S, the $\underline{\alpha} = 0$ universe frame, the energy density of all the m-groups of microwave photons is $\sum m\varepsilon F(m)$. If $\varepsilon \ll kT$, as here assumed, that energy density is essentially independent of ε; and, its value is

$$U = (\pi^4/15)\,[8\pi(kT/hc)^3]\,(kT) \cong 0.260\mathrm{eV{\bullet}cm^{-3}}. \qquad \text{(A32)}$$

In the above, T = 2.73K and k and h are Boltzmann's and Planck's constants. Thus, the total energy flow rate across planes of area A to which $\underline{\alpha}$ is parallel is given by

$$U'_{\parallel} = [AcU/4] \bullet (1 - \alpha^2)^{-\frac{1}{2}}. \qquad \text{(A33)}$$

The totals flowing in the $+\underline{\alpha}$ and $-\underline{\alpha}$ directions into planes of area A that are normal to $\underline{\alpha}$ are, respectively, given by

$$_{+}U'_{\perp} = [AcU/4] \bullet [(1 - \alpha)/(1 + \alpha)] \qquad \text{(A34)}$$

and

$$_{-}U'_{\perp} = [AcU/4] \bullet [(1 + \alpha)/(1 - \alpha)]. \qquad \text{(A35)}$$

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We are now able to define an instrument and the procedure that might be used by an observer in the S′ frame to determine his frame's $\underline{\alpha}$-signature. The instrument would have the shape of a cube whose faces each have the area A. Three pairs of opposite faces make up the six aperatures into which the microwave background photons flow. The rate of energy flow into each face is constantly monitored. The cubical apparatus is rotated, more or less at random, until one pair of opposite faces indicates each of this pair is receiving the energy of the microwave photons at the same rate; namely, at the rate given in Eq. (A33).

At this point, the random rotation is stopped; and,rotation is now restricted to proceed about a fixed axis relative to S′. That axis is a line normal to the planes of the two opposite faces that first exhibited the receipt of equal energy flow rates. Of course, the flow rates into these two faces remain equal and constant since this restricted type of rotation does not alter their orientation relative to S′. When a second pair of opposite faces shows the receipt of equal flow rates; namely, the rate given by Eq. (A33), all rotations are terminated.

The remaining pair of opposite faces will now indicate unequal flows of incoming energy. One of them will register the flow rate given by Eq. (A34) and the other the rate given by Eq. (A35). This tells the S′ observer that his frame is moving, relative to S, in the direction from the $_{+}U'_{\perp}$ face to the $_{-}U'_{\perp}$ face. In units of c, the speed, α, of the observer's frame, S′, relative to S, is readily obtained in terms of the ratio.

$$r \equiv (_{-}U'_{\perp})/(_{+}U'_{\perp}) = [(1+\alpha)/(1-\alpha)]^2. \qquad \text{(A36)}$$

The above gives

$$\alpha = (\sqrt{r} - 1)/(\sqrt{r} + 1) \qquad \text{(A37)}$$

for the speed of S′ relative to S.

In summary, the observer in S′ finds the orientation of his cubical instrument that yields equal energy flow-rate readings for two of the three pairs of opposite faces of the cube. He then determines r using the flow rates into the remaining two faces. The direction of his frame's $\underline{\alpha}$-signature vector is from the lower to the larger of these two unequal rates. That vector's length, α, given in terms of r by Eq. (A37), equals his frame's speed in units of c relative to the universe frame, S.

Of course, since U is the known quantity given by Eq. (A32), the observer in S' may also compute the value of α in terms of his cube's dimension, $\sqrt{A}$, and the measured quantities $U'_{\parallel}$, ${}_{+}U'_{\perp}$ and ${}_{-}U'_{\perp}$ via Eqs. (A33), (A34) and (A35).

APPENDIX B

PARTICLE CONVERSION EVENTS

AS SEEN

IN DIFFERENT INERTIAL FRAMES

The α-vector signature of an arbitrary inertial frame and a means for its determination have been defined in Appendix A. In addition to the conservation of mass-energy and momentum, which special relativity assures in all frames, it was postulated that Eqs. (13) and (14) must apply in the α=0 ("universe") frame if the particle conversion events

$$\mathbf{E,B} \Leftrightarrow \mathbf{E,B+e,b} \qquad \text{(B-1)}$$

are to occur. An event seen to occur in the α=0 frame will, of course, also been seen to occur in all $\alpha \neq 0$ frames. However, should an observer in an $\alpha \neq 0$ frame opt to use the two-vector formalism to express the particle properties seen in his frame, those vectors will not always satisfy Eqs. (13) and (14). Indeed, if particle mass-energy and momentum are to be transformed from frame-to-frame in accord with special relativity, only one frame can be chosen for the satisfaction of Eqs. (13) and (14). And, to construct the photon/nonphoton universe model, the unique and spacially infinite α=0 frame has been chosen as the basis of rules that govern allowed particle conversion events.

The postulate of Eqs. (13) and (14), together with the conservation laws and the formalism property of Eq. (1), makes it clear that Eq. (B-1) events are limited to those where **E**,**B** and **e**,**b** are seen to move collinearly, or to be stationary, in the α=0 frame. If seen to move codirectionally or to be stationary in S, the α=0 frame, all particles will be so seen in S', an arbitrary $\alpha \neq 0$ frame. And in such cases, Eqs. (13) and (14) will apply in both S and S'.

Where **E**,**B** and **e**,**b** are seen to move antidirectionally in S, it was found that these particles must be photons and **E**,**B** a nonphoton if Eq. (B-1) events are to occur. In the special case where the photons are seen in S to move on a line parallel to the α-vector of S', such collinearity will also be seen in S'; and, the formalism vectors will satisfy Eqs. (13) and (14) in both S and S'. It remains to examine the case where α and the photon motions are not seen to be parallel in S. In that case, special relativity precludes the collinearity of photon motion seen in S from also being observed in S'. This more general scenario is illustrated in Figure B-1.

Figure B-1a shows the view in S and Figure B-1b the view in S'. In S, the more energetic of the two photons has the energy N and the other photon an energy of n in units of ε. We identify these photons as "photon-N" and "photon-n" when referring to them in either S or S'. Various properties of these two photons and of the nonphoton formed by their fusion are summarized in Tables B1 through B4. It is understood that mass-energies are in units of ε and that momentum-magnitudes are in units of ε/c. In the second column of the lower portions of the tables, components of the unit vectors in the direction, seen to be moved by a particle, are tabulated. Note that, because of the collinearity of all momenta seen in S, all mass-energies and momenta are determinable in terms of four parameters: N, n, α and Θ. The Θ-parameter is the direction moved by photon-N as seen in S. As indicated in Figure B-1, directional angles are measured counter-clockwise from α to a particle's momentum vector.

In the third and fourth columns of the upper portions of the tables, the lengths of the particles' "electric" and "magnetic" vectors (i.e., their formalism vectors) are displayed. The lengths are computed from the mass-energies and momenta of the particles as seen in S or S′ by use of Eqs. (7) and (8). Accordingly, these lengths are expressible in terms of the same four parameters used to define the mass-energies and momenta in S and S′. For a conversion event to occur, the electric vectors of the two photons must be codirectional or antidirectional in S. In the former case, the upper signs apply in the Table B3 expressions for the nonphoton's electric and magnetic vector lengths; and, the lower signs apply in the latter case.

The unit vectors in the directions of the particles' electric and magnetic vectors are not confined to the **i**,**j** plane as are the unit vectors of their momenta. Thus, in addition to the above four parameters (N, n, α and Θ), a fifth parameter, Φ, is required to define the components of the unit vectors in the directions of the particles' electric and magnetic vectors appropriate to frames S and S′. In both frames, these two formalism vectors are normal to each other and to their particle's momentum. The meaning of the angle Φ is readily understood by noting the **k**(=**i**x**j**) components of the two formalism vectors. Φ=0 or π means a particle's electric vector is in the **i**,**j** plane. Thus, $\Phi \neq 0$ means this vector has been rotated (about its momentum vector) out of the **i**,**j** plane by the angle Φ. The three components of the unit vectors in the directions of the particles' electric and magnetic vectors are tabulated in the third and fourth columns of the lower portions of the tables.

If N=n, a stationary nonphoton is seen in S. Table B4 displays the various properties of the nonphotons formed by the headon fusion of equal energy photons in S.

As there noted, the unit-vector components of the formalism vectors in S are taken to equal those in S′ as $\alpha \rightarrow 0$.

– – – – – – – – – –

An observer in S knows that two photons will fuse if they meet headon with their electric vectors aligned collinearily. But, how does an observer in S′ know what photon-pairs will fuse? To identify such pairs, the S′-observer starts by determining his frame's α-vector. He knows that candidate pairs for fusion are those whose photons move toward a meeting in a plane to which α is parallel. He chooses one such photon whose momentum-vector **P′** makes the angle Θ′ with the α-vector (Fig. B-1b) and whose electric vector is inclined at the angle Φ with respect to the α,**P′** plane. He knows that the second photon must also have its electric vector inclined at Φ or at (π+Φ) when the two meet. He chooses the second photon with such an inclination and with a momentum vector **p′** that makes a particular angle θ′ with the α-vector. That unique angle is specified in terms of α and Θ′ by

$$\sin\theta' = -\left[(1-\alpha^2)\sin\Theta'\right] / \left[1+\alpha^2+2\alpha\cos\Theta'\right] \qquad \text{(B-2)}$$

and

$$\cos\theta' = -\left[(1+\alpha^2)\cos\Theta'+2\alpha\right] / \left[1+\alpha^2+2\alpha\cos\Theta'\right] \qquad \text{(B-3)}$$

The two photons, selected via the above procedure, will be seen in S to meet headon with their electric vectors aligned collinearily. This is the means by which an observer in S′ is able to identify which photon pairs will fuse.

Having identified a pair of photons that will fuse into a nonphoton, how does the observer in S′ predict the properties of the nonphoton? These properties are specified in Tables B3 and B4 in terms of the parameters α and Φ, which are known to the S′

observer, and N, n and Θ, which he can compute from observable input. From the photon energies, N' and n', seen in S' and the already known angles Θ' and θ', he obtains N and n via

$$N = [(1+\alpha \cos \Theta') / \sqrt{1-\alpha^2}]\, N' \tag{B-4}$$

and

$$n = [(1+\alpha \cos \theta') / \sqrt{1-\alpha^2}\,]\, n' . \tag{B-5}$$

The remaining parameter, Θ, is defined by

$$\sin \Theta = [(\sqrt{1-\alpha^2} \sin \Theta') / (1+\alpha \cos \Theta')] \tag{B-6}$$

and

$$\cos \Theta = [(\cos \Theta'+\alpha) / (1+\alpha \cos \Theta')] . \tag{B-7}$$

With N, n, α, Θ and Φ in hand, the nonphoton properties may be computed by use of the prescriptions given in the cited tables.

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In addition to identifying photon-pairs capable of fusing into a nonphoton and predicting the nonphoton's properties, the S′-observer can also pick a nonphoton at random and predict the properties of the two photons that could be born from the nonphoton's fission. For example, say he picks the nonphoton that has mass-energy $\mathcal{N}'$; that has a momentum vector of length $\mathcal{P}'$; and, that moves in the direction ψ'. In S, the nonphoton's mass-energy is seen as

$$\mathcal{N} = [(\mathcal{N}'+\alpha\mathcal{P}' \cos \Psi') / \sqrt{1-\alpha^2}] . \tag{B-8}$$

The nonphoton's momentum vector is seen in S to have the length

$$\mathcal{P} = \{[(\mathcal{P}\cos\Psi'+\alpha\mathcal{N}) / \sqrt{1-\alpha^2}]^2 + [\mathcal{P}\sin \Psi']^2\}^{1/2} \tag{B-9}$$

and to point in the direction defined by

$$\sin\Theta = [(\mathcal{P}\sin\Psi')\,/\,\mathcal{P}] \tag{B-10}$$

and
$$\cos\Theta = [(\mathcal{P}\cos\Psi' + \alpha\mathcal{N}')\,/\,(\mathcal{P}\sqrt{1-\alpha^2})]. \tag{B-11}$$

The inclination Φ of a moving nonphoton's electric vector is seen to be the same in both S and S′.

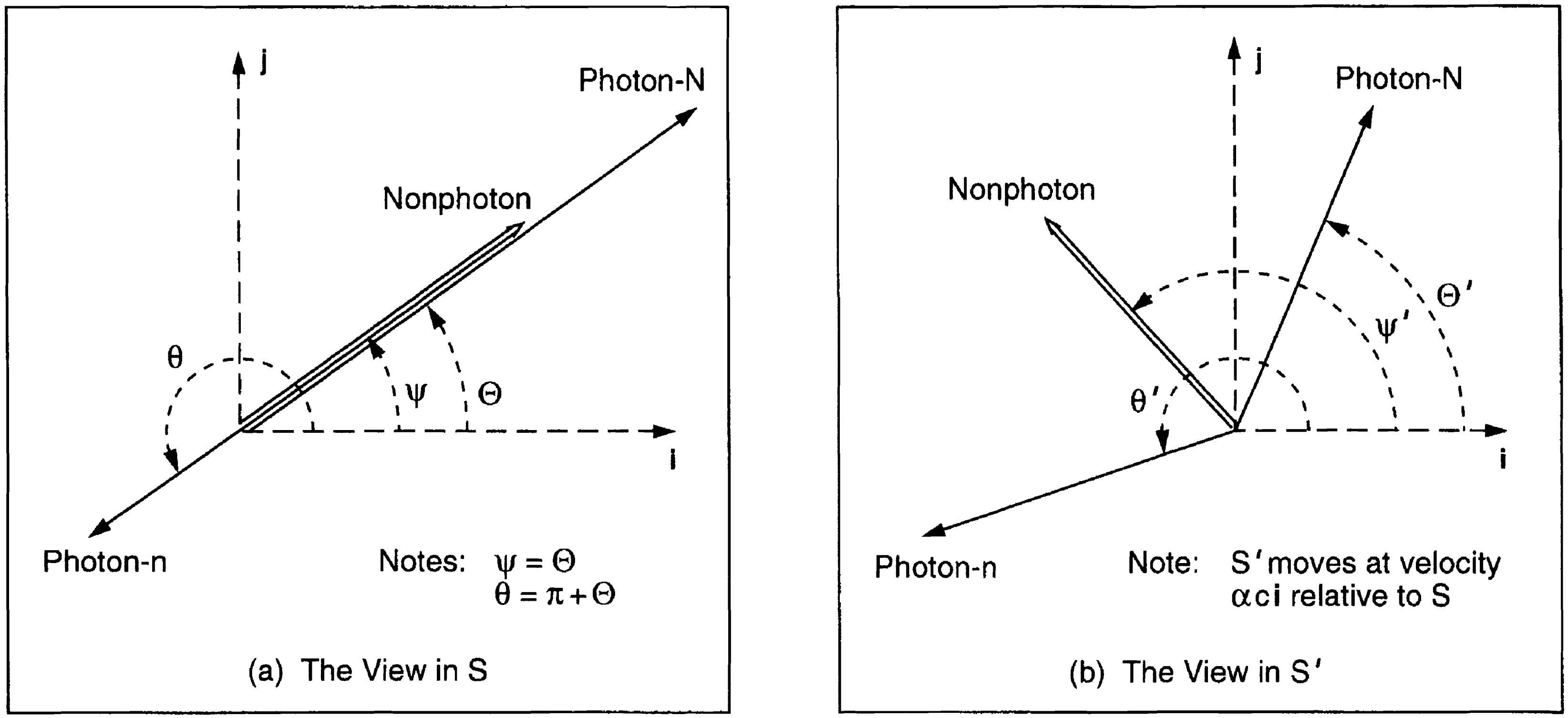
In S, the nonphoton could fission into antidirectional photons with energies of

$$\mathrm{N} = (\mathcal{N}+\mathcal{P})/2 \tag{B-12}$$

and
$$\mathrm{n} = (\mathcal{N}-\mathcal{P})/2\,, \tag{B-13}$$

where $\mathcal{N}$ and $\mathcal{P}$ are now known to the S′-observer via Eqs. (B-8) and (B-9). As seen in S, photon-N would move in the direction Θ, which is known to him via Eqs. (B-10) and (B-11).

Thus, with the full set of parameters (N, n, α, Θ and Φ) in hand, the S′-observer is now able--via the prescriptions in Tables B1 and B2--to predict all the properties of the two photons into which his selected nonphoton could fission.



Safonov, universe, figB1

Note: Figures show momentum vectors for scenario where $N = 15$; $n = 5$; $\Theta = \tan^{-1} 3/4$; $\alpha = 3/5$.

Figure B-1. Two-Photon $\rightleftarrows$ One-Nonphoton Particle Conversion Events as Seen in S and S′ Frames.

Table B-1. "Photon-N" Properties in S and S'.

Energy	Momentum Vector-length	"Electric" Vector-length	"Magnetic" Vector-length
N	N	$E = \sqrt{N/2}$	$B = \sqrt{N/2}$
$N' = [(1-\alpha\cos\Theta)/\sqrt{1-\alpha^2}]N$	$P' = [(1-\alpha\cos\Theta)/\sqrt{1-\alpha^2}]N$	$E' = [(1-\alpha\cos\Theta)/\sqrt{1-\alpha^2}]^{1/2}\sqrt{N/2}$	$B' = [(1-\alpha\cos\Theta)/\sqrt{1-\alpha^2}]^{1/2}\sqrt{N/2}$

Unit Vectors of Directed Quantities	Momentum	"Electric" Vector	"Magnetic" Vector
i component	$\cos\Theta$	$-\sin\Theta\cos\Phi$	$+\sin\Theta\sin\Phi$
	$\cos\Theta' = [(\cos\Theta-\alpha)/(1-\alpha\cos\Theta)]$	$-\sin\Theta'\cos\Phi = -[\sqrt{1-\alpha^2}\sin\Theta/(1-\alpha\cos\Theta)]\cos\Phi$	$+\sin\Theta'\sin\Phi = +[\sqrt{1-\alpha^2}\sin\Theta/(1-\alpha\cos\Theta)]\sin\Phi$
j component	$\sin\Theta$	$+\cos\Theta\cos\Phi$	$-\cos\Theta\sin\Phi$
	$\sin\Theta' = [\sqrt{1-\alpha^2}\sin\Theta/(1-\alpha\cos\Theta)]$	$+\cos\Theta'\cos\Phi = +[(\cos\Theta-\alpha)/(1-\alpha\cos\Theta)]\cos\Phi$	$-\cos\Theta'\sin\Phi = -[(\cos\Theta-\alpha)/(1-\alpha\cos\Theta)]\sin\Phi$
k component	0	$\sin\Phi$	$+\cos\Phi$
	0	$\sin\Phi$	$+\cos\Phi$

Safonov, universe tables

Table B-2. "Photon-n" Properties in S and S'.

Energy	Momentum Vector-length	"Electric" Vector-length	"Magnetic" Vector-length
n	n	$e = \sqrt{n/2}$	$b = \sqrt{n/2}$
$n' = [(1+\alpha\cos\Theta)/\sqrt{1-\alpha^2}]n$	$p' = [(1+\alpha\cos\Theta)/\sqrt{1-\alpha^2}]n$	$e' = [(1+\alpha\cos\Theta)/\sqrt{1-\alpha^2}]^{1/2}\sqrt{n/2}$	$b' = [(1+\alpha\cos\Theta)/\sqrt{1-\alpha^2}]^{1/2}\sqrt{n/2}$

Unit Vectors of Directed Quantities	Momentum	"Electric" Vector	"Magnetic" Vector
i component	$-\cos\Theta$	$\mp\sin\Theta\cos\Phi$	$\mp\sin\Theta\sin\Phi$
	$\cos\theta' = -[(\cos\Theta+\alpha)/(1+\alpha\cos\Theta)]$	$+\sin\theta'\cos\Phi = \mp[\sqrt{1-\alpha^2}\sin\Theta/(1+\alpha\cos\Theta)]\cos\Phi$	$+\sin\theta'\sin\Phi = \mp[\sqrt{1-\alpha^2}\sin\Theta/(1+\alpha\cos\Theta)]\sin\Phi$
j component	$-\sin\Theta$	$\pm\cos\Theta\cos\Phi$	$\pm\cos\Theta\sin\Phi$
	$\sin\theta' = -[\sqrt{1-\alpha^2}\sin\Theta/(1+\alpha\cos\Theta)]$	$-\cos\theta'\cos\Phi = \pm[(\cos\Theta+\alpha)/(1+\alpha\cos\Theta)]\cos\Phi$	$-\cos\theta'\sin\Phi = \pm[(\cos\Theta+\alpha)/(1+\alpha\cos\Theta)]\sin\Phi$
k component	0	$\pm\sin\Phi$	$\mp\cos\Phi$
	0	$\pm\sin\Phi$	$\mp\cos\Phi$

Safonov universe tables

Table B-3. Nonphoton Properties (N>n) in S and S'.

Mass Energy	Momentum Vector-length	"Electric" Vector-length	"Magnetic" Vector-length
$\mathcal{N} = (N+n)$	$\mathcal{P} = (N-n)$	$\mathcal{E} = \sqrt{N/2} \pm \sqrt{n/2}$	$\mathcal{B} = \sqrt{N/2} \mp \sqrt{n/2}$
$\mathcal{N}' = [(N+n) - (N-n)\alpha\cos\Theta]/\sqrt{1-\alpha^2}$	$\mathcal{P}' = \{\langle[(N-n)\cos\Theta-(N+n)\alpha]/\sqrt{1-\alpha^2}\rangle^2 + [(N-n)\sin\Theta]^2\}^{1/2}$	$\mathcal{E}' = \{1/2\langle[(N+n)-(N-n)\alpha\cos\Theta]/\sqrt{1-\alpha^2} \pm 2\sqrt{Nn}\rangle\}^{1/2}$	$\mathcal{B}' = \{1/2\langle[(N+n)-(N-n)\alpha\cos\Theta]/\sqrt{1-\alpha^2} \mp 2\sqrt{Nn}\rangle\}^{1/2}$

Unit Vectors of Directed Quantities	Momentum	"Electric" Vector	"Magnetic" Vector
i component	$\cos\Theta$	$-\sin\Theta\cos\Phi$	$+\sin\Theta\sin\Phi$
	$\cos\psi' = (1/\mathcal{P}')[(N-n)\cos\Theta - (N+n)\alpha]/\sqrt{1-\alpha^2}$	$-\sin\psi'\cos\Phi = -(1/\mathcal{P}')[(N-n)\sin\Theta]\cos\Phi$	$+\sin\psi'\sin\Phi = +(1/\mathcal{P}')[(N-n)\sin\Theta]\sin\Phi$
j component	$\sin\Theta$	$+\cos\Theta\cos\Phi$	$-\cos\Theta\sin\Phi$
	$\sin\psi' = (1/\mathcal{P}')[(N-n)\sin\Theta]$	$+\cos\psi'\cos\Phi = (1/\mathcal{P}')\langle[(N-n)\cos\Theta-(N+n)\alpha]/\sqrt{1-\alpha^2}\rangle\cos\Phi$	$-\cos\psi'\sin\Phi = -(1/\mathcal{P}')\langle[(N-n)\cos\Theta-(N+n)\alpha]/\sqrt{1-\alpha^2}\rangle\sin\Phi$
k component	0	$+\sin\Phi$	$+\cos\Phi$
	0	$+\sin\Phi$	$+\cos\Phi$

Table B-4. Nonphoton Properties (N=n) in S and S'.

Mass Energy	Momentum Vector-length	"Electric" Vector-length	"Magnetic" Vector-length
$\mathcal{N} = 2N$	$\mathcal{P} = 0$	$\mathcal{E} = [1 \pm 1]\sqrt{N/2}$	$\mathcal{B} = [1 \mp 1]\sqrt{N/2}$
$\mathcal{N}' = [1/\sqrt{1-\alpha^2}]2N$	$\mathcal{P}' = [\alpha/\sqrt{1-\alpha^2}]2N$	$\mathcal{E}' = [1/\sqrt{1-\alpha^2} \pm 1]^{1/2}\sqrt{N}$	$\mathcal{B}' = [1/\sqrt{1-\alpha^2} \mp 1]^{1/2}\sqrt{N}$

Unit Vectors of Directed Quantities	Momentum	"Electric" Vector	"Magnetic" Vector
i component	DNA	0	0
	$\cos\psi' = -1 x \alpha/\sqrt{\alpha^2}$	0	0
j component	DNA	$-\cos\Phi$	$+\sin\Phi$
	0	$+\cos\psi'\cos\Phi = -\cos\Phi$	$-\cos\psi'\sin\Phi = +\sin\Phi$
k component	DNA	$+\sin\Phi$	$+\cos\Phi$
	0	$+\sin\Phi$	$+\cos\Phi$

Safonov universe tables

Note: Unit vector components of "electric" and "magnetic" vectors in S taken to equal the components in S' (α) as $\alpha \rightarrow 0$.

APPENDIX C

DERIVATION OF RELATIONSHIPS BETWEEN EVENT-PROBABILITY PARAMETERS

Under equilibrium conditions, the population of nonphotons of energy $m\varepsilon$, born from the head-on fusion of a photon of energy $n\varepsilon$ with one of energy $(m-n)\varepsilon$, remains--on the average--constant. That is, via the fission death of nonphotons, photons are born; via the fusion death of photons, nonphotons are born; and, constant population requires that particle birth rates equal particle death rates. Below, we consider the events that occur in a unit volume where particle populations equal the particle number densities, $F_{m,n}$, prescribed by Eq. (39).

The nonphoton birthrate is proportional to the product $F_{n,o}xF_{(m-n),o}$. The nonphoton death rate is assumed to consist of two components: death by spontaneous fission and death by photon-induced fission. The spontaneous component is proportional to $F_{m,n}$ and assumed independent of the photon environment. The induced component has two subcomponents: one proportional to $F_{n,o}xF_{m,n}$ and the other to $F_{(m-n),o}xF_{m,n}$. Our objective here is to derive connections between the various constants of proportionality.

The nonphoton birth rate may be written as $F_{n,o}xc\mu_{n,(m-n)}xF_{(m-n),o}$. Here, c is the speed of light in vacuum and $c\mu_{n,(m-n)}$ is the constant of proportionality associated with the birth process. The quantity $\mu_{n,(m-n)}$ plays the role of a microscopic cross section for photon-photon fusion. We may regard $cF_{n,o}$ as the "flux" of photons that bombards "target" photons of number-density $F_{(m-n),o}$ and $\mu_{n,(m-n)}$ as the cross section for the fusion of flux-photons with target-photons.

The spontaneous component of the nonphoton death rate may be written as $(1/\tau_{m,n})xF_{m,n}$. Here, $\tau_{m,n}$ is the "e-folding decay time" of the nonphotons in an environment without photons. The photon flux $cF_{n,o}$ induces nonphoton fission at the rate $F_{n,o}xc\mu_{n,m}xF_{m,n}$ and the photon flux $cF_{(m-n),o}$ at the rate $F_{(m-n),o}xc\mu_{(m-n),m}xF_{m,n}$.

Equating the nonphoton birth rate to the sum of its various death rates, we have

$$F_{n,o}xc\mu_{n,(m-n)}xF_{(m-n),o} = [(1/\tau_{m,n})+F_{n,o}xc\mu_{n,m}+F_{(m-n),o}xc\mu_{(m-n),m}]\,xF_{m,n}. \qquad \text{(C-1)}$$

Solving for $1/\tau_{m,n}$ and using Eq. (39), we obtain

$$1/\tau_{m,n} = 8\pi c(\varepsilon/hc)^3 \Big\{ \mu_{n,(m-n)} \big\langle [n^2+2\Delta]\cdot[(m-n)^2+2\Delta]\cdot[e^{\gamma m}-1] \big\rangle \,x$$

$$\big\langle [(m-2n)^2+(2-\delta_m^{2n})\Delta]\cdot[e^{\gamma n}-1]\cdot[e^{\gamma(m-n)}-1] \big\rangle^{-1}$$

$$-\,\mu_{n,m}\,[n^2+2\Delta]\cdot[e^{\gamma n}-1]^{-1}$$

$$-\,\mu_{(m-n),m}[(m-n)^2+2\Delta]\cdot[e^{\gamma(m-n)}-1]^{-1} \Big\}, \qquad \text{(C-2)}$$

where γ has been written for ε/kT.

To obtain the desired connections between the various above-mentioned constants of proportionality, we use the fact that $1/\tau_{m,n}$ is assumed to be independent of the photon environment. That environment is defined by the system temperature T; and, therefore by $\gamma=\varepsilon/kT$—or, equivalently, by e^γ. This means $\partial(1/\tau_{m,n})/\partial(e^\gamma)= 0$ for all values of m and n. Carrying out the differentiation and requiring that the multipliers of $e^{\gamma q}$ vanish for all q-values, we obtain the connections expressed by Eqs. (53), (54) and (55) of the text.

It may be noted that had we assumed Boltzmann or Fermi-Dirac statistics for the nonphotons rather than Bose-Einstein statistics, we could not have found a $1/\tau_{m,n}$ prescription that is independent of the system parameter ε/kT which--via T—determines the system's photon environment. That is, for the spontaneous fission rate of nonphotons to be independent of the photon environment, out of the three types of statistics mentioned, it is necessary to choose the Bose-Einstein type.

APPENDIX D

PHOTONIC RING MODELS

OF

THE ELECTRON, PROTON AND NEUTRON

Reference 7 describes photonic ring models of the electron and its antiparticle that conform with four of their important properties: mass, charge, angular momentum and magnetic moment. Photonics of two types (photons with plus or minus electric charges) move in opposite directions along two neighboring rings in numbers prescribed to assure conformity. To define similar models of the proton and the neutron and their antiparticles, we add a third photonic species: electrically neutral photons. The size of a model with three neighboring rings and the relative populations of each photonic type are prescribed in terms of the above-cited four particle properties.

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All photonics are assumed to have the same energy δ. Those that are not neutral are assumed to carry a charge of magnitude ζ. The quantities δ and ζ are regarded as fundamental since the same values are used to construct a ring model of the electron, the proton and the neutron and their antiparticles.

The total number of photonics in the model of a particle of mass M is given by

$$Mc^2/\delta = N^o + N^+ + N^- \ . \qquad \text{(D1)}$$

N^o represents the total number of neutral photonics; N^+, the total of those with $+\zeta$ charges; and, N^-, the total of those with $-\zeta$ charges.

Equating the net charge of the photonic system to that of the particle it models, one has

$$Q/\zeta = N^+ - N^-, \qquad \text{(D2)}$$

where $Q = 0$, $+e$ or $-e$ for a member of particle trio under consideration

Two or three circles, all of radius R, represent the orbits of a model's photonics. The circles' planes are parallel and closely spaced; and, their centers lie on the model's "axis", a line normal to these planes. On one circle, all N^+ photonics orbit the axis in one direction. On a second circle, all N^- photonics orbit in the opposite direction. For the nucleons, $N^0 \neq 0$. And, on a third ring, we assume all N^0 photonics orbit in the direction that enhances the net angular momentum of the charged photonics.

Every particle of the trio under consideration has an angular momentum of magnitude $h/4\pi$. This requires that

$$hc/(4\pi\delta R) = N^0 \pm (N^+ - N^-). \qquad \text{(D3)}$$

Here, the upper sign applies if $N^+ > N^-$ (i.e., $Q = +e$) and the lower if $N^- > N^+$ (i.e., $Q = -e$).

The electric currents of the N^+ and N^- photonics are in the same direction since these oppositely charged entities orbit in opposite directions. Equating a particle's magnetic moment to that of its photonic ring model, yields the equation

$$\mu eh/(2\pi Mc\zeta R) = N^+ + N^-. \qquad \text{(D4)}$$

Above, μ represents the magnitude of a particle's magnetic moment in units of $eh/(4\pi Mc)$.

It is to be noted that Eqs. (D3) and (D4) relate the positive numbers N^0, N^+ and N^- to the magnitudes of two vector quantities: angular momentum and magnetic moment respectively. The relative direction of these parallel vectors depends on the particle and is defined later.

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The above four equations relate the four parameters, R, N^o, N^+ and N^-, of a particle's photonic ring model to its properties M, Q, $h/4\pi$ and μ and the presumed "photonic fundamentals", δ and ζ. Solving the equations for the model parameters one obtains

$$R = \frac{hc/4\pi\delta + \mu eh/2\pi Mc\zeta}{Mc^2/\delta \pm Q/\zeta}, \tag{D5}$$

$$N^o = \frac{(hc/4\pi\delta)\,(Mc^2/\delta) \mp (Q/\zeta)\,(\mu eh/2\pi Mc\zeta)}{(hc/4\pi\delta + \mu eh/2\pi Mc\zeta)}, \tag{D6}$$

$$N^+ = (1/2)\left[\frac{(\mu eh/2\pi Mc\delta)\cdot(Mc^2/\delta \pm Q/\zeta)}{(hc/4\pi\delta + \mu eh/2\pi Mc\zeta)} + (Q/\zeta)\right], \tag{D7}$$

and
$$N^- = (1/2)\left[\frac{(\mu eh/2\pi Mc\delta)\cdot(Mc^2/\delta \pm Q/\zeta)}{(hc/4\pi\delta + \mu eh/2\pi Mc\zeta)} - (Q/\zeta)\right]. \tag{D8}$$

Above, the upper sign applies for a particle with a net charge of $Q = +e$ or 0, and the lower for its antiparticle for which $Q = -e$ or 0. Since the value of $\pm Q$ is the same for a particle and its antiparticle, R and N^o are the same for both. The values of N^+ and N^-, of course, simply interchange as one goes from a particle to its antiparticle as evident from Eqs. (D7) and (D8).

For the leptons, we take $\mu = 1$ and $N^o = 0$. Substituting these values into Eq. (D6) and writing m for the electron mass, one finds that this requires that δ and ζ be related according to

$$\delta/\zeta = (1/\sqrt{2})\cdot(mc^2/e). \tag{D9}$$

By use of this $\delta-\zeta$ connection and the three definitions

$$\eta \equiv (1/\sqrt{2})\,(m/M), \tag{D10}$$

$$\Lambda \equiv h/2\pi Mc \tag{D11}$$

and,
$$N \equiv Mc^2/\,\delta, \tag{D12}$$

the prescriptions for a photonic ring model's parameters may be simplified. Note that the Λ quantity is — or may be regarded as — the Compton wavelength of a particle of mass M. And, as evident from Eq. (D1), N represents the total population of the photonics in the model of a particle with this mass.

For the $Q/e = \pm 1$ particles, the parameter equations read

$$R/\Lambda = (1/2)\,(1+2\mu\eta)\big/(1+\eta), \tag{D13}$$

$$N^o/N = (1-2\mu\eta^2)\big/(1+2\mu\eta), \tag{D14}$$

$$(N^+/N) = (\eta/2)\,[2\mu(1+\eta) \pm (1+2\eta)]\big/(1+2\mu\eta) \tag{D15}$$

and
$$(N^-/N) = (\eta/2\,[2\mu(1+\eta) \mp (1+2\eta]\big/(1+2\mu\eta). \tag{D16}$$

The upper signs apply to $Q/e = +1$ particles and the lower to their antiparticles for which $Q/e = -1$.

For the $Q/e = 0$ particles (i.e., the neutron and antineutron), the model parameters are prescribed by

$$R/\Lambda = (1/2)\cdot(1+2\mu\eta), \tag{D17}$$

$$N^o/N = 1/\,(1+2\mu\eta) \tag{D18}$$

and
$$N^+/N = N^-/N = (\eta/2)\cdot[2\mu\,/\,(1+2\mu\eta)]. \tag{D19}$$

With zero net charge, the Q=0 neutron and its antiparticle must be distinguished via other means. Experiments (Ref. 14) find that the neutron's angular momentum vector is antidirectional to its magnetic moment vector. Hence, we construct the photonic ring model of the neutron accordingly. And, as for all the particles under consideration, one of these vector directions is reversed in going from particle to antiparticle. (The right hand screw convention is used to establish a vector's direction.)

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To estimate the values of the ring model parameters for the electron, proton and neutron, we use the various input quantities shown in Table D1. Primary input are the Mc^2 and μ values which are close to those found in Ref. 15. Table D2 shows the parameter values computed by use of Table D1 input.

As indicated in the top row of Table D2 the value of R/λ is $1/\sqrt{2}$ for the leptons and is very close to 1/2 for the nucleons. In the second through fourth rows, the fractional population figures (N^o/N, N^+/N and N^-/N) are shown. How a particle's Mc^2 energy is distributed amongst its photonic species is indicated in the last three rows. As evident from the fifth row figures, the charged photonic population of the nucleons must be a few times that of the leptons. For the particles with a net charge, of course, $|N^+-N^-|$ is the same; and this explains the 0.361 MeV entries of the sixth row. The bottom row shows that almost all of the nucleons' Mc^2 energy is carried by their neutral photonic populations, as required for these heavy, but small R, particles to have the same angular momentum as the light, but larger R, leptons.

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A complete definition of particle photonic ring models requires a knowledge of the value of δ. Given this, the total photonic population of a particle of mass M is defined via $N = Mc^2/\delta$. And, with a particle's N-value in hand, the total numbers of each of the three types of photonics, N^o, N^+ and N^-, may be obtained by multiplying N by the population-fraction values shown in rows two, three and four of Table D2.

Table D-1. Assumed Input Quantities.

Quantity (units)	Electron	Proton	Neutron
Q/e	–1	1	0
Mc^2 (MeV)	0.511	938.3	939.6
μ ($eh/4\pi Mc$)	1	2.793	1.915
Vector Orientations *	↑↓	↑↑	↑↓
m/M	1	5.4460×10^{-4}	5.4385×10^{-4}
η	$1/\sqrt{2}$	3.851×10^{-4}	3.845×10^{-4}
$\mu\eta$	$1/\sqrt{2}$	1.0756×10^{-3}	0.7363×10^{-3}
Λ (cm)	3.862×10^{-11}	2.103×10^{-14}	2.100×10^{-14}

Safonov, universe, tableD1-2

* Arrows indicate relative orientations of spin and magnetic moment vectors on basis of the "right hand screw" convention. Neutron's vectors drawn per Ref. 14 discussion of experimental findings.

Table D-2. Photonic Ring Model Parameters.

Parameter	Electron	Proton	Neutron
R/Λ	$1/\sqrt{2}$	(1/2) (1.0017650)	(1/2) (1.0014726)
N°/N	0	0.9978526	0.9985296
N^+/N	0.146447	0.001266	0.0007352
N^-/N	0.853553	0.0008814	0.0007352
$[(N^+ + N^-)/N]\ Mc^2$	0.511 MeV	~2.015 MeV	~1.382 MeV
$[\lvert N^+ - N^- \rvert/N]\ Mc^2$	~0.361 MeV	~0.361 MeV	0
$(N^\circ/N)\ Mc^2$	0	936.285 MeV	938.218 MeV

Safonov, universe, tableD1-2

APPENDIX E

ON MATTER AND LIGHT

This appendix is a copy* of Reference 1, one of the author's 1949 notes on the idea that a system of photon-like particles confined to a small space could have the gross properties of the then-conceived "fundamental" particles (e.g., the electron, proton and neutron). In 2000 and early 2001, we resumed this line of thought to further the construction of models of such particles in terms of photonics that move along circular orbits (Ref. 7 and 8). To complete the construction process, in late 2001 the idea of confining a particle's photonics to a small ring-like volume via the action of nonphotons was utilized (Ref.9, and also see Section VI of this document).

* Page 4 of the text of this old unedited note's text correctly refers to the conservation of momentum and energy. In writing its abstract on its cover, we inadvertently wrote "mass" for the word "momentum".

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2-5-49
G. Safonov

O N   M A T T E R   A N D   L I G H T

George Safonov - February 5, 1949

The special relativity Doppler equation is applied to a photon describing a closed path. The time average behavior of this photon is notedly similar to that of a mass equal to the photon's energy divided by the square of the velocity of light. In particular, it is noted that light confined within a small space has the gross properties of a particle. The microscopic properties of such confined photons could explain "intrinsic" spin. The conservation of mass and energy for all types of collisions are natural consequences of such an inner structure.

ON MATTER AND LIGHT

The Lorentz equations connect the space-time coordinates of an event observed by S and S'. S and S' are observers moving at a constant velocity, βc, (c is velocity of light) with respect to each other. They locate objects with respect to their individual rectangular coordinate systems which coincide at some initial instant. S' moves away from S down the positive x axis. The transformation equations are

$$(1) \qquad x = \frac{x' + \beta c t'}{\sqrt{1 - \beta^2}}$$

$$(2) \qquad t = \frac{t' + \beta \frac{x'}{c}}{\sqrt{1 - \beta^2}}$$

$$(3) \quad y, z = y', z'$$

From (1), (2), and (3) one may derive the frequency shift or Doppler effect for light of frequency ν' radiated from a source at rest in S'. S will observe a frequency

$$(4) \quad \nu = \nu' \frac{1 + \beta \cos \theta'}{\sqrt{1 - \beta^2}}$$

Above θ' is the angle between the direction of the radiation and x'. This angle is observed by S as

$$(5) \quad \cos \theta = \frac{\beta + \cos \theta'}{1 + \beta \cos \theta'}$$

We consider a photon, observed by S' to move along a closed path (as one reflected back and forth between two fixed mirrors). We consider the possibility that the frequency ν' may change during the cycle (as, say, by Compton collision); so we write $\nu' = \nu'(t')$. We compute the time average frequency that S would observe for such a photon; we assume (4) and (5) to hold at every point of the cycle. By use of (4) this time average is computed from

$$(6)\quad \overline{\nu} = \frac{1}{\tau}\int_0^{\tau} \nu'(t')\,\frac{1+\beta\cos\theta'}{\sqrt{1-\beta^2}}\,dt$$

Here τ is the period of the cycle as viewed by S. From (2) we find

$$(7)\quad dt = \frac{1+\frac{\beta}{c}\frac{dx'}{dt'}}{\sqrt{1-\beta^2}}\,dt'$$

We note that

$$(8)\quad \cos\theta' = \frac{dx'}{ds'} = \frac{1}{c}\,\frac{dx'}{dt'}$$

and $(9)\quad \tau' = \tau\sqrt{1-\beta^2}$

In (9) τ' is the period of the cycle observed by S'. Substituting (7), (8), and (9) into (6) we obtain

$$(10)\quad \overline{\nu} = \frac{1}{\sqrt{1-\beta^2}}\;\frac{1}{\tau'}\int_0^{\tau'} \nu'(t')\,dt' + \frac{1}{\sqrt{1-\beta^2}}\;\frac{\beta}{c\,\tau'}\int_0^{\tau'} \nu'(t')\left[2+\frac{\beta}{c}\frac{dx'}{dt'}\right]\frac{dx'}{dt'}\,dt'$$

The second integral in (10) is evaluated below

$$\int_0^{\tau'} \nu'(t')\left[2+\frac{\beta}{c}\frac{dx'}{dt'}\right]\frac{dx'}{dt'}\,dt' = \int_{x_0'}^{x_0'} \nu'\left[2+\frac{\beta}{c}\frac{dx'}{dt'}\right]dx' = 0$$

In the last step above, the integrand is considered as a function of x'; the integral vanishes since the orbit is closed in S'. Thus (10) may be written as

$$(11) \quad \overline{\nu} = \frac{\overline{\nu'}}{\sqrt{1-\beta^2}}$$

Next we consider the time average of $\nu \cos\theta$ as observed by S. This is found by a calculation similar to that preceding (11); the result is

$$(12) \quad \overline{(\nu \cos\theta)} = \frac{\beta}{\sqrt{1-\beta^2}} \overline{\nu'}$$

If the energy and momentum of a photon are proportional to its frequency (as $E = h\nu$ and $P = \frac{h\nu}{c}$), we find

$$(13) \quad \overline{E} = \frac{\overline{E'}}{\sqrt{1-\beta^2}}$$

$$(14) \quad \overline{P_x} = \frac{\beta}{c\sqrt{1-\beta^2}} \overline{E'}$$

(13) relates the time average energies viewed by S and S' as the photon goes through its cycle. (14) gives the time average of the x component of the photon's momentum, P_x, as viewed by S in terms of its time average energy as viewed by S'.

A material mass, m, translating down the positive x axis with a speed βc would have a momentum equal to that computed in (14), if

$$(15) \quad m = \frac{1}{\sqrt{1-\beta^2}} \cdot \frac{\overline{E'}}{c^2} = \frac{\overline{E}}{c^2}$$

This is, of course, in accord with Einstein's mass-energy equivalence principle.

We have shown that the time average behavior of a photon, moving in a closed orbit in S' is similar to that of a translating material object when viewed by S. The "rest mass", m_0, of the equivalent object would be $\overline{E'}/c^2$ as found by setting $\beta = 0$ in (15). We find the appropriate dependence of mass on velocity as

$$m = \frac{m_0}{\sqrt{1-\beta^2}} \tag{16}$$

S and S' would regard the circulating photon as matter if the deviations from the time average mass would not critically affect the experiment at hand. They would regard it as a point mass if it were confined in a space sufficiently small.

It may be shown that if momentum and energy are conserved for a photon-photon collision in one system, they are conserved in all systems moving at constant velocities with respect to each other. Thus two groups of circulating photons would collide as two material objects, and momentum and energy would be conserved for all observers. If the material fundamental particles had a photon-like substructure, the conservation of momentum and energy would be assured for all kinds of collisions.

In regard to this last statement, we consider the electron. It is evidently necessary to attribute an angular momentum, $h/4\pi$, to this particle. Let the electron have a material microscopic structure of total rest mass μ. In order to obtain a maximum angular momentum, let this mass move with constant speed βc along a circle of radius r. Then we have

$$\frac{h}{4\pi} = \frac{\mu\beta c}{\sqrt{1-\beta^2}} \cdot r \tag{17}$$

The mass represented by this particle is

$$m_0 = \frac{\mu}{\sqrt{1-\beta^2}} \tag{18}$$

Thus r must be

$$(19) \qquad r = \frac{h}{4\pi \beta c m_e}$$

r is smallest when β is near its limiting value, 1. We compute this minimum value as $r = \frac{137}{2} r_e$; r_e is the classical electron radius.

It does not seem possible to obtain a reasonable radius with a material inner structure moving at nearly the speed of light. We note that $\mu = 0$ and $\beta = 1$ lead to an indeterminancy in (17); these values are not excluded however. They could satisfy (17) and again suggest a photon-like microscopic structure for the material particles. The interchange of light and matter observed in pair production and annihilation does not contradict the notion of matter as a form of light.

APPENDIX F

OTHER NONPHOTON ROLES

In the text, we noted that nonphotons play multiple roles in a photon-nonphoton universe. They give the microwave background photons "something to be in equilibrium with"; they act to maintain the photonics of electrons, protons and neutrons in dynamic equilibrium as they move inside thin string-like annular regions; and, they collide elastically with the photonic constituents of weighable bodies to explain the Newtonian gravity acting between such bodies. Here, we note that nonphotons might also play a role that mimics that of some form of "dark matter" and another role that mimics a repulsive gravitational force between bodies made up of photonic constituents.

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To illustrate its dark matter role, we consider the nonphotons in a spherical region of an infinite photon-nonphoton universe. Outside the sphere the nonphoton inertial-mass density is ρ_o and inside that density is incrementally larger, being $\rho_o + d\rho_o$. According to Eqs. (48) and (50), in an equilibrium microwave-photon-nonphoton mix, the nonphoton inertial mass density is proportional to T^5, where T is the mix temperature. We assume the slightly larger density inside the sphere reflects that equilibrium there was attained at a slightly higher temperature; namely, at $T + dT$. Thus, we have

$$d\rho_o = 5\,\rho_o(dT/T) \tag{F1}$$

To mimic dark matter, the microscopic cross section, σ_o, for the elastic scattering of one average nonphoton via a collision with another must be very small, but finite. Due to $d\rho_o$, the macroscopic cross section, $\wedge_o^{-1}$, for such collisions is incrementally larger inside the sphere by the amount

$$d(\wedge_o^{-1}) = (d\rho_o/\mu) \cdot \sigma_o = 5 \cdot (\rho_o/\mu) \cdot (dT/T) \cdot \sigma_o. \tag{F2}$$

Above, μ represents the inertial mass of the average moving nonphoton as seen in the universe frame. Observations indicate $dT/T \sim 10^{-5}$ for microwave photons seen in patches of the observable universe (Ref 21). We will use this 10^{-5} figure to estimate a value of σ_o.

For conventional gravity theory calculations to conform with the observed motions of bodies in a galaxy, a density $d\rho$ of dark matter that is, typically, about ten times that of visible matter must be assumed (Refs. 22 and 23). Since the average density of visible matter is $\sim 10^{-30}$ grams/cm^3, we will assume $d\rho = 10^{-29}$ grams/cm^3. Let $d(\wedge^{-1})$ denote the contribution of dark matter to the macroscopic cross section, $\wedge^{-1}$, of the visible and dark matter objects in the sphere under consideration. According to nonphoton gravity theory, we have

$$d(\wedge^{-1}) = (c^2 d\rho/\delta) \cdot \bar{\sigma}, \qquad \text{(F3)}$$

where δ and $\bar{\sigma}$ are given by Eqs. (114) and (117), respectively.

For the nonphotons making up $d\rho_o$ to mimic the gravitational effect of the photonics making up $d\rho$, it is required that $d\wedge_o^{-1}$ equal $d\wedge^{-1}$. This condition is satisfied if

$$\sigma_o = (\mu c^2/\delta) \cdot (d\rho/d\rho_o) \cdot \bar{\sigma} = (1/5)\,(\mu c^2/\delta) \cdot [(d\rho/\rho_o)/(dT/T)] \cdot \bar{\sigma}. \qquad \text{(F4)}$$

The value of ρ_o is given by Eq. (111), that of δ by Eq. (114); that of μc^2 by Eq. (52); and, that of $\bar{\sigma}$ by Eq. (117). By use of those values, we estimate

$$\sigma_o \cong 8.92 \times 10^{-121}\ \mathrm{cm}^2. \qquad \text{(F5)}$$

The mean free path for nonphoton-nonphoton elastic collision is thus estimated at

$$\wedge_o = (1/D\sigma_o) = 5.3 \times 10^{40}\ \mathrm{cm} \cong 5.3 \times 10^{22}\ \text{light years}, \qquad \text{(F6)}$$

where D is the nonphoton number density given by Eq. (110). Such a large $\wedge_o$ is quite compatible with the nonphoton gravity concept.

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Let us now consider the effect of nonphoton gravity on a photonic body exterior to a sphere of galactic dimension in an infinite T = 2.73K photon-nonphoton universe. The exterior equilibrium mix of microwave photons and nonphotons is at temperature T; and, the interior mix is slightly cooler, being at temperature T–dT. If the sphere contains no photonic matter, the force of nonphoton gravity on an exterior photonic body would be directed away from the sphere's center. If the interior contained photonic matter at an average density $d\rho$, the repulsive force would just vanish if

$$|dT/T| = (1/5)(\mu c^2/\delta)(\bar{\sigma}/\sigma_o)(d\rho/\rho_o). \tag{F7}$$

For a $d\rho$ of 10^{-30} grams/cm^3, we find that if the interior is cooler than the exterior such that $dT = -10^{-6} \cdot T$, exterior photonic matter would feel no gravitational force. And, for still cooler interiors, an exterior photonic body would feel a repulsive force—one that pushes it away from the galactic sphere. In this sense, we say nonphotons could mimic a repulsive gravitational force.

APPENDIX G

REGARDING EQUATION (100)

Unless otherwise stated, the following relates to the "view" in S, the "universe frame". In that frame, the directional nonphoton flux would be isotropic in zero gravity regions and only weakly anisotropic in regions where Newtonian-level gravity exists.

To derive Eq. (100) of the text, we consider a circle of radius r whose center is at a distance R(>>r) from a line in the circle's plane. Rotating the plane about the line, one generates a thin ring of volume $V = 2\pi^2 Rr^2$. Interior to the ring are uniformly distributed photonics that move codirectionally along circles centered on the ring's axis (i.e., the above-cited line). The photonics' total inertial mass is denoted by M. Of course, the symbols r, R, V and M are understood to represent quantities as seen in frame-S where the thin-ring of circulating photonics is seen at rest in an infinite sea of isotropically moving nonphotons.

We assume the photonics are so closely packed that incoming nonphotons that impact them cannot penetrate their domain. Since R>>r, slightly more surface is exposed to incoming nonphotons that would push the photonics toward the ring's axis than the surface exposed to the nonphotons that would push them away from the axis. Thus, although most impacts would yield equal and opposite forces on the photonic system, a net inward force would result due to the cited differences in exposed surface areas.

We denote by p the pressure that would be felt by a surface that perfectly reflects nonphotons. We assume our ring of closely packed photonics, being impenetrable to nonphotons, reacts to their impacts as if the ring's surface perfectly reflects them. And, since $r \ll R$, all parts of the ring's surface are assumed to feel the same pressure p.

A small portion of the ring lies between two planes that intersect along its axis. We denote the angle between these planes by $\varphi(\ll 2\pi)$. The net inward force due to the pressure acting on that portion is $\pi r^2 p\varphi$. The inertial mass of the photonics between these planes is $(\varphi/2\pi)M$ and the magnitude of the momentum of those photonics is $(\varphi/2\pi)Mc$. The rate change of the momentum is $[(\varphi/2\pi)Mc] \times c/R$, the change of momentum being directed toward the ring's center. Dynamic equilibrium requires that

$$\pi r^2 p\varphi = [(\varphi/2\pi)Mc] \times (c/R), \qquad \text{(G1)}$$

a condition that yields Eq. (100) of the text; namely, $pV = Mc^2$.

According to the prescriptions of special relativity, if the ring is seen in the universe frame, S, to move at a speed of βc in the direction of its axis, its inertial mass becomes $M/\sqrt{(1-\beta^2)}$ and its volume contracts to $V\sqrt{(1-\beta^2)}$.

The moving rings' contained-photonics will be seen to move along helical paths on the surfaces of cylinders of radii equal to ~R. The radii of curvature of those helices equal ~$R/\sin^2\theta$, where $\theta = \cos^{-1}\beta$ is the angle between the cylinder's axis and a tangent to the helical trajectories of the photonics contained in the contracted-volume ring seen in S. Thus, the radius of curvature of a photonic's trajectory is $R/(1-\beta^2)$ in S in the case of a ring-like "particle" moving at βc in the direction of its axis.

We note that the pressure $p = (M/V)c^2$ that assures dynamic equilibrium for the stationary (β=o) ring particle also assures such equilibrium for the moving (β>o) particle. In terms of the previously defined small angle φ, the net inward force on a small portion of the contracted ring due to the pressure p is $[\pi r^2\sqrt{(1-\beta^2)}]\, p\varphi$. The inertial mass of this portion is $(\varphi/2\pi)\, M/\sqrt{(1-\beta^2)}$; and, the magnitude of its momentum would be $(\varphi/2\pi)\ Mc/\sqrt{(1-\beta^2)}$. The rate-change of its momentum would be $(\varphi/2\pi)\ [Mc/\sqrt{(1-\beta^2)}] \times c \times [(1-\beta^2)/R]$; the change of momentum being directed toward the ring's center.

For the β>o case, dynamic equilibrium would be had if

$$[\pi r^2\sqrt{(1-\beta^2)}]\, p\varphi = (\varphi/2\pi)\, [Mc/\sqrt{(1-\beta^2)}] \times c \times (1-\beta^2)/R, \qquad \text{(G-2).}$$

Cancelling out the $(1-\beta^2)$ terms, the above reduces to the Eq. (G1) condition. That is, the same pressure p that assures dynamic equilibrium of the ring-like particle at rest in S also assures such equilibrium when the particle moves in the direction of its axis at arbitrary ($1>\beta>o$) speeds in S.

Note that—in zero gravity regions of S, the universe frame—the above ring-like particle would "coast" unimpeded along a straight line at the constant speed βc. And, the mass energy and momentum of the ring-like particle equals that of a point-like particle of the same rest mass M that moves at speed βc. Also, it may be noted that the angular momentum, McR, of the ring-like particle about the ring's axis is independent of its speed under the above conditions.

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