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# The Steady-State Free-Electron Population of Free Space.

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*Summary.* – The author's structured space model by which the fine-structure constant and the proton/electron mass ratio have been determined is now shown to contain a very rarified disordered matter state, whose free-electron population of approximately $10^{-27}$ kg/m$^3$ presents a scattering cross-section limiting the visible universe to the measured range of $10^{10}$ light years.

In an earlier letter (1) presenting a derivation of the fine-structure constant it was suggested that space may have properties associated with a characteristic cubic-cell of lattice dimension $d = 72\pi e^2/m_e c^2$, a characteristic frequency $\nu = m_e c^2/h$ and a characteristic threshold energy quantum which analysis gave as the combined energy of 1843 electrons. This led to a value of $\alpha^{-1}$ of

$$(1) \qquad 108\pi(8/1843)^{\frac{1}{6}} = 137.035915\,.$$

Above, $e$ is the electron charge, $m_e$ the electron mass, $c$ the speed of light *in vacuo* and $h$ is Planck's constant. $\alpha$ is the fine-structure constant.

The theory also indicated that space may well be populated by virtual energy quanta, equivalent to having a muon pair in each cell. In 1975 this model was applied to the exact derivation of the proton/electron mass ratio (2), the dual muon energy constituting the nucleus on which the proton form was synthetized. Recently, by regarding these muon constituents as point charges migrating at random at the frequency $\nu$, the model has found further application in explaining and evaluating the muon lifetime (3), the neutron lifetime (4) and the pion lifetime (5). Furthermore, the critical energy threshold

(1) H. ASPDEN and D. M. EAGLES: *Phys. Lett. A*, **41**, 423 (1972).
(2) H. ASPDEN and D. M. EAGLES: *Nuovo Cimento A*, **30**, 235 (1975).
(3) H. ASPDEN: *Physics Unified* (Sabberton, Southampton, 1980), p. 146.
(4) H. ASPDEN: *Lett. Nuovo Cimento*, **31**, 383 (1981).
(5) H. ASPDEN: *Lett. Nuovo Cimento*, **33**, 237 (1982).

set by the $1843 m_e c^2$ quantum was crucial to the neutron lifetime determination and is of significance, on stability criteria, to the creation of the proton.

Physically, this quantum arises because each cubic cell has a lattice charge element $q$ set in a uniform background continuum of opposite-charge density and the condition for which $q$ can change in form without displacing the continuum is that it absorbs energy to create $N$ electrons and positrons occupying the same volume. Thus

$$q \rightleftharpoons N(e^-, e^+) . \tag{2}$$

The argument is that $q$ has to be at zero or near zero potential in relation to all other $q$ charge and continuum charge. This fixes the cubic structure and the position of $q$ in relation to the centre of each cell. The dynamics of the space model are linked to the properties of the electron and the physical size of the electron charge in relation to that of $q$. The analysis shows ([1]) that a true zero potential condition would correspond to a nonintegral value of $N$ lying between 1844 and 1845. Since the potential cannot be negative for a true vacuum state $N$ has to be lower than this and it must be odd to cater for electron-positron pair creation and $q$ converting to an electron or positron. Thus $N$ is 1843.

The pair of virtual muons in each cell were identified as such because they assure energy equilibrium by giving the cell the same energy density as the $q$ elements. Analysis indicated that their mass was very slightly less than the mass of a real muon. The same analysis ([6,7]), applying the Thomson formula relating charge radius and energy, allowed the volume of $q$ to be determined as $(1/N)^{\frac{1}{3}}(m_e/2m_\mu)d^3$, where $m_\mu$ is the mass of the virtual muon.

The advance now to be presented in this paper is based on the simple realization that in free space the transition indicated by eq. (2) will occur naturally but with a very low probability. It takes the energy of nine virtual muons to exceed the energy threshold set by $Nm_e c^2$, with $N = 1843$. The virtual-muon mass is a little in excess of $206 m_e c^2$. Therefore, we look to the event when four muon pairs plus one muon of charge opposite to $q$ all combine within the volume of $q$ in the same cycle of migration. The muon pairs have a random freedom of movement and are not confined to a particular cell. The chance of one muon entering the $q$ volume is one in $(1/N)^{\frac{1}{3}}(m_e/2m_\mu)$. Therefore, the chance of nine muons entering this same volume at the same time is this factor raised to the power 9. The logic of this supposes that each muon arrives independently and simultaneously and that the chance of four negative muons appearing is the factor raised to the power 4, whereas the chance of five positive muons appearing is the factor raised to the power 5, the total chance being the product of the two. We find that the overall effect is that at any time the chance of a $q$ element converting according to eq. (2) is $(1/N)^3(m_e/2m_\mu)^9$. It is supposed that the reverse transition occurs at the end of each cycle when the muons migrate to new positions. In effect, however, the condition just described is ever present and is a steady-state condition.

The formula given in the introductory paragraph can be used to evaluate $d$ as $6.37 \cdot 10^{-11}$ cm, meaning that there are $3.87 \cdot 10^{36}$ cells in a cubic metre of space. With $N = 1843$ and $m_\mu/m_e = 207$ it is evident that one cell in $2.2 \cdot 10^{33}$ is subject to the transition just discussed. There are, therefore, approximately 1.760 excited electron cells in each cubic metre of free space.

The state of excitation involves a $q$ charge becoming an electron and the nine muons shedding energy and creating 921 electron-positron pairs to leave the residual energy

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([6]) H. Aspden: *Physics Unified* (Sabberton, Southampton, 1980), p. 103.

([7]) H. Aspden: *Physics without Einstein* (Sabberton, Southampton, 1969), p. 118.

nucleated in a positive charge of larger energy content, but physically very much smaller in size than the electron. The question then is whether 1760 such systems in each cubic metre of free space might be detected owing to the disorder they represent in what is otherwise a transparent and wholly ordered medium.

The electron-positron pairs will not obstruct the passage of electromagnetic waves because they have a mutual inertial balance and are collectively neutral in their response to electric fields. This leaves the electrons, 1760 per cubic metre, as the dominant factor presenting a scattering cross-section to radiation. The Thomson-scattering cross-section of an electron is well established as $2.1\cdot 10^{-29}\ \text{m}^2$ and, accordingly, our theory tells us that the free vacuum should present a cross-section of $3.7\cdot 10^{-26}\ \text{m}^2$ per metre cubed. On average, therefore, a photon would have to travel at the speed of light $3\cdot 10^8$ m/s for $9\cdot 10^{16}$ seconds before being wholly absorbed. Such a phenomenon could well pass undetected. The mass density of the electron population causing this obstruction of radiation is as low as $1.6\cdot 10^{-27}\ \text{kg/m}^3$, which is curiously of the order of the mean mass density seen in the galaxies and attributed to the so-called missing mass in cosmological theory.

There is purpose in examining whether the scattering process just discussed has some bearing upon the cosmological red-shift. Universal expansion by which the red-shift becomes a cosmological Doppler effect is the accepted hypothesis. The alternative provided by the « tired light » hypothesis, which requires the degeneration of frequency in transit, is discounted by MISNER, THORNE and WHEELER (8) who quote ZEL'DOVICH (9). He stressed that the statistical nature of photon interception by particles in the interstellar space would require some photons to lose more energy than others, resulting in a spectral line broadening that is not observed. Yet, space is so tenuous that one may well question how one can be sure that a statistical interception process applies when the particles involved are about 10 cm apart. The physics of our experimental experience was not developed from observations on tenuous media having such ultra-rarified character. It may well be unwarranted speculation to rely on the Zel'dovich argument.

There is something very special about the true vacuum that is never mentioned in this context. It has the ability to transmit waves without frequency dispersion, the very property that ZEL'DOVICH sees as missing when matter is present. The author (10) has recently discussed this zero dispersion vacuum property and argues that space itself must adapt to the local wave disturbance so as always to be in tune locally with the signal in transit. Furthermore, this frequency property must somehow be codified at each point in space-time without regard to whatever happens at adjacent points and without involving the propagation speed $c$.

The author has shown that this state of affairs applies if one accepts that the electric field vector $E$ is a composite of two electric field vector components $E_1$ and $E_2$ having separate physical significance. This allows us to write two equations:

$$E = E_1 - E_2\,, \tag{3}$$

$$\frac{\mathrm{d}E}{\mathrm{d}t} = (E_1 - E_2)F(E_1/E_2)\,, \tag{4}$$

where $t$ is time and $F$ is a function of the ratio of $E_1$ and $E_2$. The rate of change of the amplitude of an electromagnetic wave can be codified in this way in terms of the strengths

(8) C. W. MISNER, K. S. THORNE and J. A. WHEELER: *Gravitation* (Freeman, San Francisco), p. 775.
(9) Y. B. ZEL'DOVICH: *Sov. Phys. Uspekhi*, **6**, 475 (1964).
(10) H. ASPDEN: *Wireless World*, **88**, 37 (1982).

of two electric-field components at the point in question. It need not be determined by the speed at which the wave progresses to adjacent points.

The function $F$ is governed by the condition that there is zero frequency dispersion, at least up to the threshold frequency at which electrons and positrons are created. One can infer that at this limit $E_2$ is zero, whereas at frequencies in the radio and optical spectrum $E_1$ and $E_2$ are approximately equal, even though their actual ratio is a crucial indicator of the frequency.

With such a feature electromagnetic theory admits the possibility that the presence of matter could attenuate $E_1$ and $E_2$ unequally, that is, not in linear proportion. In this case the ratio $E_1/E_2$ can change and the frequency might vary in transit. In the quantum situation, where collective action of intercepting matter co-operates in a photon reaction, the change is substantial and the frequency is reduced in a quantum step, but in a very rarified interstellar medium, the frequency will reduce progressively as each element of matter is intercepted to scatter energy.

The analysis involves analogy with a simple harmonic oscillator for which the linear restoring force rate is a variable giving a resonant frequency $f$, where

$$f^2 = k\nu^2 . \tag{5}$$

The variable $k$ is equal to $E/E_1$, this being $1-E_2/E_1$. It gives $E_2 = 0$ when $f = \nu$, as already mentioned, $\nu$ being the Compton frequency of the electron.

For a sinusoidal planar wave the amplitude of $\mathrm{d}E/\mathrm{d}t$ is $2\pi fE$ or $2\pi\nu k^{\frac{1}{2}}(E_1 - E_2)$, which is of the form given by eq. (4) because $k$ is a function of $E_1/E_2$. Also, $E_1$ and $E_2$, though approximately equal in magnitude over much of the frequency spectrum, are associated with relatively very different charge densities and inversely so related to very different physical displacements. This causes one of them to be the seat of almost all wave energy loss so that $E_1$ is effectively constant in a planar wave and $E_2$ is the main variable.

The energy density $W$ of such a wave is proportional to $E^2$ or $(kE_1)^2$, which means that $(1/W)\,\partial W$ can be written as $(2/k)\,\partial k$. Also, from (5), with $\nu$ constant, we find that $(2/f)\,\partial f$ is $(1/k)\,\partial k$. Taken together, these relationships allow us to write

$$\frac{1}{f}\frac{\partial f}{\partial x} = \frac{1}{4W}\frac{\partial W}{\partial x}\,, \tag{6}$$

where $x$ is the distance travelled by the wave.

We arrive, therefore, at the remarkable proposition that the dual-component electric displacement, needed to explain the zero dispersion property of the vacuum, gives it the property of attenuating the frequency of waves in transit at one quarter of the rate at which the wave energy is absorbed, subject to overriding quantum effects present with matter. In the true vacuum where only the electron induction process discussed in this paper causes any attenuation, there should be a progressive reduction of frequency with a time constant of $3.6\cdot 10^{17}$ s, that is four times the period calculated for energy attenuation. This is 11400 million years, a quantity comparable with the 12000 million years estimated as the average age of the galaxies as judged from their spectral character ([11]).

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([11]) J. NARLIKAR: *The Structure of the Universe* (Oxford University Press, 1977), p. 228.
([12]) D. H. GIESKIENG: *The Mines Magazine* (January, 1981), p. 29.

The author sees the contribution in this paper as a major advance in a theory of the structured vacuum which has been evolving for many years. It is extremely gratifying that a theory which has proved to be so fruitful in determining fundamental constants with high precision should so easily lead to the theoretical derivation of the most relevant constant in cosmology. The interpretation of Hubble's constant as a phenomenon linked to dual displacement in the field medium should now encourage experimental enquiry into the detection of this property of radiation, one avenue being the study of the anomalous antenna properties reported by GIESKIENG ([12]). The author hopes to report on this in due course.