A New Explanation for the Red Shift

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Abstract

The concept of a universal ideal elastic medium is developed to show that protons, neutrons and stars can be represented as stress patterns whose characteristics are determined by the structure of the hydrogen atom and the nature of thermal radiation. One characteristic of the stress pattern of a star such as the sun is the radial velocity of light in the pattern, which is shown to be a function of both the distance from the star and the mass of the star. This velocity is equivalent to Hubble's velocity of recession.

Introduction

The notion of an expanding universe originated more than a century ago when it was found that Einstein’s theory of general relativity allowed either expansion or contraction. Einstein himself believed that the universe was static but was converted to expansion by Hubble’s astronomical observations. Hubble calculated the distance of certain stars from the earth and related these distances to the redshift of light transmitted from the stars, showing a rough proportionality. Together with an assumed linear relation between the recessional velocity of a star and the redshift of light from the star, this gave Hubble’s law of proportionality between velocity and distance.

There is a problem with this law in that the assumed relationship between recessional velocity and redshift can be justified for low velocities but the velocities required to explain the redshift are large and can exceed the velocity of light. Further problems which have emerged in recent years are that measurements of Hubble’s constant of proportionality differ by amounts which have not been explained, and redshift surveys have shown that an apparently accelerating expansion of the universe requires the existence of a hypothetical “dark” energy of large magnitude. No evidence for the existence of such an energy has been found. If dark energy does not exist then neither does expansion of the universe and an alternative explanation for the redshift is necessary.

It has been suggested that a new physics may be required to address the above problems and ideally to resolve the lack of connection between quantum theory and general relativity. Yet perhaps it is not a new theory that is required but rather the old science of applied mechanics.

The concept of a universal ideal elastic medium in which mass is equated to strain energy offers an approach to the solution of several long-standing problems in theoretical physics. Radiation permeates the entire universe and in part one of the following article it is shown that protons can be represented as spherical patterns of radiation pressure and mechanical stress. The characteristics of a proton stress pattern are derived from a purely mechanical mathematical model of a hydrogen atom in which the single electron is represented as a standing wave which spins about a circumferential axis within the spherical pattern. This model includes both black body radiation and the radiation spectrum of a hydrogen atom.

In part two, the form of the strong nuclear force is defined as the result of the formation of a helium nucleus from the fusion of two proton stress patterns.

In part three, it is proposed that the velocity of light is a function of the density of the medium in which it is transmitted and relates this to the velocity of light in a neutron stress pattern. In this case the velocity is shown to increase as a linear function of the distance from the centre of the stress pattern. Assuming that the sun can also be represented as a spherical pattern of radiation and stress with a similar function for the radial velocity of light in the pattern, it is shown that this velocity is consistent with Hubble's law. In the proposed model light travels from a star to the earth with increasing velocity and wavelength as a function of both the distance travelled and the mass of the star. This function can be tested by application to multiple stars of different masses.

This alternative to Hubble's law does not require either expansion of the universe or the existence of dark energy to power such an expansion.

Stress patterns are of theoretically infinite extent although tenuous at cosmic distances. This suggests that all stress patterns are in contact with all other stress patterns and offers an explanation of Einstein's spooky action at a distance and of entanglement.

PART 1. A MECHANICAL MODEL OF THE HYDROGEN ATOM

1. Introduction

Planck's formula for black body radiation may be expressed as an infinite series from which radiation energy density can also be derived as a series. These expressions lead to alternative mechanical descriptions of the nature of black body radiation and the fundamental particles which constitute an atom. This alternative model includes a background level of mass density as a constant of integration.

2. Planck's formula

One expression of Planck's formula for black body radiation is $dU = \dfrac{Ad\lambda}{\lambda^5 (e^{B/\lambda} - 1)}$ J m^{-3} (1)

where U is the radiant energy density, λ is the wavelength of the emitted radiation, $A = 8\pi hc$ $B = hc / kT$, h is Planck's constant, c is the velocity of light, k is Boltzmann's constant and T is absolute temperature. For an alternative to Planck's formula let $dU = \dfrac{Ad\lambda}{\lambda^5} e^{-B/\lambda} f(\lambda)$

then $f(\lambda) = \dfrac{e^{B/\lambda}}{e^{B/\lambda} - 1} = \dfrac{1}{1 - e^{-B/\lambda}} = 1 + e^{-B/\lambda} + e^{-2B/\lambda} + e^{-3B/\lambda} + \ldots$ and Planck's formula

expressed as an infinite series is therefore $dU = \dfrac{Ad\lambda}{\lambda^5} (e^{-B/\lambda} + e^{-2B/\lambda} + e^{-3B/\lambda} + \ldots)$ (2)

In this form, the increment $\delta U = \dfrac{dU}{d\lambda} \delta\lambda$ represents an increase in the energy density in a black body enclosure whereas the energy density measured by an external sensor corresponds to a decrease in the energy density in the enclosure. Changing the sign of Eq.(2) therefore gives the energy density as

$$U = -A\int \frac{1}{\lambda^5}\left(e^{-B/\lambda} + e^{-2B/\lambda} + e^{-3B/\lambda} + ...\right) d\lambda \quad (3)$$

where $\int e^{-B/\lambda}\frac{d\lambda}{\lambda^5} = e^{-B/\lambda}\int \frac{d\lambda}{\lambda^5} - B\int \frac{1}{\lambda^2}e^{-B/\lambda}\int \frac{d\lambda}{\lambda^5} = -\frac{e^{-B/\lambda}}{4\lambda^4} + \frac{B}{4}\int \frac{e^{-B/\lambda}}{\lambda^6}d\lambda$

giving from the first term of Eq.(3) $U = \frac{Ae^{-B/\lambda}}{4\lambda^4} + \frac{ABe^{-B/\lambda}}{20\lambda^5} + \frac{AB^2e^{-B/\lambda}}{120\lambda^6} + ...$ and a first approximation to the radiation energy density given by Eq. (3) is therefore

$$U = \frac{Ae^{-B/\lambda}}{4\lambda^4} + \frac{Ae^{-2B/\lambda}}{4\lambda^4} + \frac{Ae^{-3B/\lambda}}{4\lambda^4} + ... + U_B \quad \text{or}$$

$$U = \frac{A}{4\lambda^4}\left(e^{-B/\lambda} + e^{-2B/\lambda} + e^{-3B/\lambda} + ...\right) + U_B \quad (4)$$

The form of this equation (in which U_B is a constant of integration) leads to an alternative description of the nature of black body radiation.

3. Spherical radiation patterns

Suppose that at a particular radiation temperature in the early universe, spherical patterns of radiation energy density and pressure were formed in an electromagnetic field. It is assumed that in these patterns, radial radiation pressures at all radii are in equilibrium with the stresses produced by electrostatic forces. Assuming that the radial force on an element of a spherical radiation pattern is analogous to that given by Newton's law for the gravitational force on an element of a solid sphere, i.e.

$$\delta F = \frac{Gm\delta m}{r^2} \quad (5)$$

where m is the total mass of the pattern, δm is the mass of the element, r is the distance of the element from the centre of the pattern and G is the gravitational constant.

The electrostatic force is then

$$\delta F = \frac{\sigma Gm\delta m}{r^2} \quad (6)$$

where σ is the ratio of electrostatic force to gravitational force. The total radiation energy of a spherical pattern of radius r can be expressed as the mass energy

$$mc^2 = 4\pi\int_0^r Ur^2 dr \quad (7)$$

where U is the radiant energy density as a function of radius. From Eqs.(6),(7) the electrostatic force on the element is

$$\delta F = \frac{4\pi\sigma G\delta m}{c^2r^2}\int_0^r Ur^2 dr \quad (8)$$

The volume of an element of a spherical shell subtended by orthogonal angles $\delta\theta$ and $\delta\phi$ is $\delta V = r^2\delta\theta\delta\phi\delta r$ where r is the radius of the shell and δr is the thickness. In a radiation pattern the energy of the element is $\delta mc^2 = U\delta V = Ur^2\delta\theta\delta\phi\delta r$. For the equilibrium of the shell, the electrostatic force between the element and the centre of the pattern is equal to the force due to radiation pressures on the shell. In the particular case where the force due to a radiation pressure difference δp acts towards the centre of the pattern and is repulsed by electrostatic force, Eq.(8) gives

$$(p+\delta p)(r+\delta r)^2\delta\theta\delta\phi - pr^2\delta\theta\delta\phi = 4\pi\sigma G\frac{U}{c^4}\delta\theta\delta\phi\delta r\int_0^r Ur^2 dr$$

$$(p+\frac{dp}{dr}\delta r)(r^2+2r\delta r) - pr^2 = 4\pi\sigma G\frac{U}{c^4}\delta r\int_0^r Ur^2 dr$$

$$r^2\frac{dp}{dr}+2rp = 4\pi\sigma G\frac{U}{c^4}\int_0^r Ur^2 dr \tag{9}$$

For the outer region of a spherical pattern in which the mass m given by Eq.(7) is assumed to be a variable which approaches a constant value with increase in radius, the force on the element approaches that given by Eq.(6). In this region the integral in the above equation approximates to an integral with an infinite upper limit, giving from Eqs.(7),(9) $r^2\frac{dp}{dr}+2rp = \sigma Gm\frac{U}{c^2}$ where m is the total mass of the pattern. The radial pressure due to transverse radiation waves is $p = U/3$ and with this substitution,

$$r^2\frac{dp}{dr}+2rp = 3\sigma Gmp/c^2 = bp \tag{10}$$

where $$b = 3\sigma Gm/c^2 \tag{11}$$

From this $r^2\frac{dp}{dr} = -\{2r-b\}p$ or $\frac{dp}{p} = -\left\{\frac{2}{r}-\frac{b}{r^2}\right\}dr$ and integrating,

$\log p = -2\log r - \frac{b}{r} + \log C = \log\frac{C}{r^2} + \log(e^{-b/r})$ where C is a constant of integration, giving

$$p = \pm\frac{C}{r^2}e^{-b/r} \tag{12}$$

This function defines the radial radiation pressure at large radii in a static spherical pattern.

4. Discussion

The existence of a spherical radiation pattern depends on a condition of static equilibrium between radiation pressure and a stress provided by a force of attraction or repulsion. No solution has been found to the equilibrium equation when radiation energy density is replaced by strain energy density, but the presence of a stress pattern having the same form as a radiation pattern may be assumed. In the case of a background level of uniform radiation pressure and stress, consider a linear element having a cross-sectional area a, a length l and a total radiation energy $W = Ual = 3pal$. If an external force produces an extension δl, the volume of the element increases to $a(l+\delta l)$, the radiation energy density decreases to $W/a(l+\delta l)$ and the radiation pressure decreases to $p = W/3a(l+\delta l)$. The restoring force produced by this change in radiation pressure is

$$F = a\left\{\frac{W}{3al} - \frac{W}{3a(l+\delta l)}\right\} = \frac{W}{3l}\left\{1-\left(1+\frac{\delta l}{l}\right)^{-1}\right\}$$

At small values of $\delta l/l$ this approximates to $F = \frac{W}{3l}\left\{1-\left(1-\frac{\delta l}{l}\right)\right\} = \frac{W}{3l}\frac{\delta l}{l}$ and the restoring force is therefore approximately proportional to the displacement. This suggests that the medium of uniform radiation pressure in which spherical radiation patterns are assumed to have formed has the characteristics of an elastic material, which allows the application of elastic theory. In a linear element of this medium, radiation pressure and stress are given by $p = \frac{F}{a} = \frac{W}{3al}\frac{\delta l}{l}$ and in an elastic material, the direct stress is $p = E\frac{\delta l}{l}$ where E is the elastic modulus. The modulus of the radiation medium is therefore proportional to the radiation energy density.

It is assumed that proton constituents, protons and atoms can be represented as spherical stress and radiation patterns and that following the formation of proton constituent mass at a particular temperature in the early universe, the characteristics of pressure, stress and elastic modulus at this temperature were preserved in the patterns and remained constant as the surrounding radiation temperature, elastic modulus and stress decreased.

5. Proton stress patterns

If radiation pressure in a spherical pattern is equated to radial stress, then from Eq.(12)

$$p = \pm\frac{C}{r^2}e^{-b/r} = p_r \tag{13}$$

where C and b are constants, r is the radius at a point within the pattern and p_r is the radial stress. From elastic theory (assuming a value of 1/3 for Poisson's ratio) the strain energy per unit volume in a spherical stress pattern is

$$U_S = \frac{1}{2E}\left\{p_r^2 + \frac{4}{3}p_\theta^2 - \frac{4}{3}p_r p_\theta\right\} \tag{14}$$

where p_θ is the circumferential stress and E is the elastic modulus. Assuming that the stress pattern is incompressible, it can be shown that the circumferential stress is

$$p_\theta = -\frac{p_r}{2} \tag{15}$$

The strain energy density in the pattern is then $U_S = \frac{p_r^2}{E} = \frac{4p_\theta^2}{E}$ (16)

From the above equation and Einstein's law of equivalence the mass density in a spherical pattern is

$$\rho = \frac{U_S}{c^2} = \frac{p_r^2}{Ec^2} = \frac{4p_\theta^2}{Ec^2} \tag{17}$$

The substitution of elastic strain energy density for radiation energy density in Eq.(7) gives from Eqs.(13),(16)

$$mc^2 = 4\pi\int_0^\infty U_S r^2 dr = 4\pi\frac{C^2}{E}\int_0^\infty e^{-2b/r}\frac{dr}{r^2}$$

or

$$m = \frac{2\pi C^2}{bc^2 E}\left[e^{-2b/r}\right]_0^\infty = \frac{2\pi C^2}{bc^2 E} \tag{18}$$

where m is the mass of a proton. Eq.(13) indicates that there are two forms of spherical stress pattern in which the stresses in one pattern are of opposite sign to those of the other form.

6. Wave motion in a spherical stress pattern

The mode of vibration of a uniform ring of elastic material is a sinusoid on the developed circumference of the ring. Assuming that this is also true for vibration on the circumference of a sphere, it is suggested that the electron in a hydrogen atom can be represented as a sinusoidal half-wavelength on a circumference within a spherical stress pattern which represents a proton. It is assumed that the initial circumferential stress in an element of the pattern is tensile and that the waveform of the element can be represented as that of a stretched string. In a waveform, bending stresses in a filament of infinitesimal thickness can be neglected. To maintain zero volumetric strain, shear deflection must occur at a constant element length as shown in the following figure.

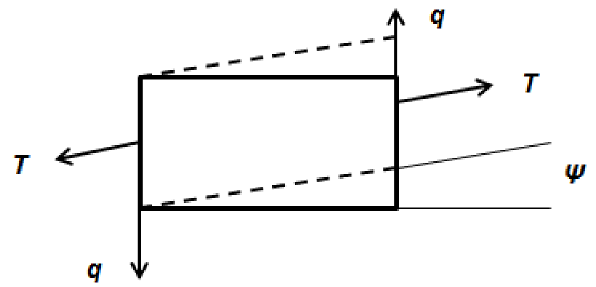


Figure 1. The shear deflection and tensile force in a waveform element

Wave formation therefore produces an additional tensile force T corresponding to a shear stress q and a shear strain ψ as shown. The tensile stress in a wave filament is then

$$p = p_\theta + E\left(\sec\psi - 1\right) \tag{19}$$

where ψ is also the angle between the wave and its circumferential axis at any point on the waveform. At small shear strains the above equation approximates to

$$p = p_\theta + \frac{1}{2}E\psi^2 \tag{20}$$

where E is assumed to be the elastic modulus at the temperature of formation of primordial hydrogen nuclei. From this, the strain energy per unit volume in a wave filament is

$$U_S = \frac{4p^2}{E} = \frac{4}{E}\left\{p_\theta^2 + Ep_\theta\psi^2 + \frac{E^2\psi^4}{4}\right\} \tag{21}$$

For a standing wave of the form $y = a\sin\frac{2\pi s}{\Lambda}\cos\frac{2\pi vt}{\Lambda}$ where y is the radial deflection, a is the amplitude, s is the circumferential length, Λ is the circumferential wavelength, v is the wave velocity and t is time, the strain angle is $\psi = \frac{dy}{ds} = \frac{2\pi a}{\Lambda}\cos\frac{2\pi s}{\Lambda}\cos\frac{2\pi vt}{\Lambda}$ and the radial velocity of wave vibration is $v_a = \frac{dy}{dt} = -\frac{2\pi va}{\Lambda}\sin\frac{2\pi s}{\Lambda}\sin\frac{2\pi vt}{\Lambda}$. The wave velocity is given by $v = \sqrt{T/\mu}$ where T is the tension in the filament and μ is the mass per unit length of the filament. Alternatively, $v = \sqrt{p_\theta/\rho}$ and substituting for the density ρ from Eq.(17), the velocity of a progressive wave at a given stress condition is $v = c\sqrt{E/4p_\theta}$. The nature of an electron wave in a three-dimensional stress pattern is speculative. It is possible to visualise the wave as a rotating stress pattern, in which case a single filament becomes a complete ring of elements at a toroidal radius a on a circumference of radius r, and the vibrational velocity

v_a becomes the projection of a constant rotational velocity v_a at the radius a, where the rotational velocity is equal to the peak value of vibrational velocity. Values of v_a and the toroidal radius at which it applies are then representative of the entire pattern and the defining equations of the standing wave become $y = a\sin\frac{2\pi s}{\Lambda}$, $\psi = \frac{2\pi a}{\Lambda}\cos\frac{2\pi s}{\Lambda}$ and $\frac{v_a}{v} = -\frac{2\pi a}{\Lambda}$. At zero volumetric strain, the volume of a wave element is independent of the wave displacement y and from Eq.(21) the total strain energy of one half-wavelength in one plane of vibration is

$$S = \delta A\int_0^{\Lambda/2} U_S ds = \frac{4\delta A}{E}\int_0^{\Lambda/2}\left\{p_\theta^2 + Ep_\theta\left(\frac{2\pi a}{\Lambda}\right)^2\cos^2\frac{2\pi s}{\Lambda} + \frac{E^2}{4}\left(\frac{2\pi a}{\Lambda}\right)^4\cos^4\frac{2\pi s}{\Lambda}\right\}ds$$

$$= \frac{4\delta A}{E}\left\{p_\theta^2\frac{\Lambda}{2} + Ep_\theta\left(\frac{2\pi a}{\Lambda}\right)^2\frac{\Lambda}{4} + \frac{E^2}{4}\left(\frac{2\pi a}{\Lambda}\right)^4\frac{3\Lambda}{16}\right\} \quad \text{or}$$

$$S = 4\frac{p_\theta^2}{E}\frac{\Lambda}{2}\delta A + 4\frac{\Lambda}{2}\delta A\left\{\frac{p_\theta}{2}\left(\frac{2\pi a}{\Lambda}\right)^2 + \frac{3}{8}\frac{E}{4}\left(\frac{2\pi a}{\Lambda}\right)^4\right\}$$

where δA is the cross-sectional area of a representative filament. From Eq.(16) the first term in the above expression represents the initial strain energy in a static filament. The second term represents the strain energy of one half-wavelength in one plane of vibration and at a particular circumferential stress $p_\theta = E/4$ the velocity of a progressive wave is $v = c$ and the total strain energy of one half-wavelength in two perpendicular planes of vibration is $S = 2E\frac{\Lambda}{2}\delta A\left\{\left(1 + \frac{1}{2}\frac{v_a^2}{c^2} + \frac{3}{8}\frac{v_a^4}{c^4}\right) - 1\right\}$. It is assumed that this is an approximation to the alternative form

$$S = 2E\frac{\Lambda}{2}\delta A\left\{\left(1 - \frac{v_a^2}{c^2}\right)^{-1/2} - 1\right\} \tag{22}$$

This expression is similar in form to the relativistic kinetic energy of a particle moving with a linear velocity. If strain energy is expressed in terms of mass, the kinetic energy in the above equation can be written as

$$T = m_E c^2\left\{\left(1 - \frac{v_a^2}{c^2}\right)^{-1/2} - 1\right\} \tag{23}$$

where $m_E = E\Lambda\delta A/c^2$ is the rest mass of an electron. One of the deficiencies of the Bohr model of the atom is that it gives a non-zero value for the ground state of orbital angular momentum of the electron. Eq.(23) represents the relativistic kinetic energy of a wave as a mass m_E rotating about a circumferential axis with zero orbital velocity. Equating this energy to that of the rest mass of an electron gives $m_E c^2\left\{\left(1 - \frac{v_a^2}{c^2}\right)^{-1/2} - 1\right\} = m_E c^2$ from which

$$\frac{v_a}{c} = \frac{\sqrt{3}}{2} \tag{24}$$

If the wave also has an orbital velocity v_r the maximum possible orbital velocity occurs when the resulting helical velocity is $\sqrt{v_r^2+v_a^2}=c$ from which

$$\hat{v}_r = c\sqrt{1-\frac{v_a^2}{c^2}} = \frac{c}{2} \tag{25}$$

7. Electron energy levels

Eq.(19) shows that the tensile stress in a wave filament is increased by the formation of a transverse wave. At the points where a sine wave crosses the circumferential axis, wave formation also produces an additional circumferential stress

$$E(\sec\hat{\psi}-1)\cos\hat{\psi} = E(1-\cos\hat{\psi}), \text{ where } \hat{\psi}=v_a/v$$

It is assumed that this increase in stress results in a change in the radial position of an electron wave within a spherical stress pattern. The circumferential stress in a wave filament is therefore $p_\theta = p_0 + E(1-\cos\hat{\psi})$ where p_0 is the circumferential stress in a proton stress pattern at the ground state of an electron. It should be noted that the value of ψ in Eq.(19) is a variable, whereas circumferential stress depends on the maximum value of ψ given by $\hat{\psi}=v_a/v$. A variation in the total energy of an electron wave which has zero orbital velocity in all radial positions requires a change in the representative velocity v_a and a corresponding change in radial position and circumferential stress. Let the circumferential stresses at two radial positions of an electron wave be $p_{\theta 1} = p_0 + E(1-\cos\hat{\psi}_1)$ and $p_{\theta 2} = p_0 + E(1-\cos\hat{\psi}_2)$. At small values of $\hat{\psi}_1$ and $\hat{\psi}_2$ these equations approximate to $p_{\theta 1} = p_0 + \frac{E}{2}\hat{\psi}_1^2 = p_0 + \frac{E}{2}\frac{v_{a1}^2}{v^2}$ and $p_{\theta 2} = p_0 + \frac{E}{2}\hat{\psi}_2^2 = p_0 + \frac{E}{2}\frac{v_{a2}^2}{v^2}$. It may be noted that the form of a spherical stress pattern given by Eqs.(13),(15) produces an energy gradient of opposite sign to that of the Bohr model, so that higher spectroscopic energy levels occur at smaller radii. The decrease in circumferential stress when an electron wave is transferred from a radius r_1 to a larger radius r_2 (assuming that the conditions at both radii approximate to those at which $v=c$) is then

$$p_{\theta 1} - p_{\theta 2} = \frac{E}{2}\left\{\frac{v_{a1}^2}{c^2} - \frac{v_{a2}^2}{c^2}\right\} \tag{26}$$

From Eq.(23) the decrease in kinetic energy corresponding to this transfer is

$$T_1 - T_2 = m_E c^2\left\{\left(1-\frac{v_{a1}^2}{c^2}\right)^{-1/2}\right\} - m_E c^2\left\{\left(1-\frac{v_{a2}^2}{c^2}\right)^{-1/2}\right\}$$

and this approximates to

$$T_1 - T_2 = \frac{m_E c^2}{2}\left\{\frac{v_{a1}^2}{c^2} - \frac{v_{a2}^2}{c^2}\right\} \tag{27}$$

From Eqs.(26),(27) the decrease in kinetic energy is

$$T_1 - T_2 = \frac{m_E c^2}{E}\left(p_{\theta 1} - p_{\theta 2}\right) \tag{28}$$

At large radii, the form of a spherical stress pattern given by Eqs.(13),(15) approximates to

$p_\theta = C / 2r^2$, giving from the above equation $$T_1 - T_2 = \frac{Cm_E c^2}{2E}\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right) \tag{29}$$

The formation of a transverse electron wave is accompanied by a longitudinal wave of the same wavelength and at all permitted radii it is assumed that a circumference contains a whole number of longitudinal wavelengths. Assuming that an electron can be represented as a sinusoidal half-wavelength of a rotating wave, an electron may occupy the position of any one of n longitudinal waves in a circumference of radius $r = n\Lambda / \pi$ where n is the number of half-wavelengths in a circumference. Eq.(29) may then be written as

$$T_1 - T_2 = \frac{\pi^2 Cm_E c^2}{2E}\left(\frac{1}{n_1^2\Lambda_1^2} - \frac{1}{n_2^2\Lambda_2^2}\right) \tag{30}$$

If a single photon is created by a decrease in the energy level of an electron, then since the electron is assumed to be stationary at both energy levels, the energy of the photon is equal to the decrease in energy level of the electron and from Eq.(30)

$$T_1 - T_2 = \frac{hc}{\lambda} = \frac{\pi^2 Cm_E c^2}{2E}\left(\frac{1}{n_1^2\Lambda_1^2} - \frac{1}{n_2^2\Lambda_2^2}\right) \text{ giving } \frac{1}{\lambda} = \frac{\pi^2 Cm_E c}{2Eh}\left(\frac{1}{n_1^2\Lambda_1^2} - \frac{1}{n_2^2\Lambda_2^2}\right) \tag{31}$$

where λ is the wavelength of the photon. Since differences in spectral energy levels are four orders of magnitude less than the minimum energy of an electron it is assumed that changes in electron wavelength associated with spectral radiation can be neglected. In this case Eq.(31) approximates to

$$\frac{1}{\lambda} = \frac{\pi^2 Cm_E c}{2Eh\Lambda^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \tag{32}$$

where $\Lambda \approx \Lambda_1 \approx \Lambda_2$. For half-wavelength electrons the circumference at the highest energy level $(n_1 = 1)$ contains two half wavelengths and in a hydrogen atom, one of these half wavelengths contains an electron. Bohr's formula for the wavelength of a photon emitted from a hydrogen atom when an electron jumps from a state n_1 to a state n_2 is

$$\frac{1}{\lambda} = R\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$$

where R is Rydberg's constant. The ground state of the electron is defined by the value $n_2 = 1$ and the radius at the ground state is the Bohr radius $a_0 = \dfrac{h}{2\pi\alpha m_E c} = \dfrac{\Lambda_c}{2\pi\alpha}$ where $\Lambda_c = \dfrac{h}{m_E c}$ is the Compton wavelength of an electron and $\alpha = 7.29735.10^{-3}$ is the fine structure constant. The wavelength of the electron is therefore $\Lambda = 2\pi a_0 = \dfrac{\Lambda_c}{\alpha}$ and substituting these values in Eq.(32) gives

$$\frac{1}{\lambda} = \frac{\pi^2\alpha^2}{2\Lambda_c^3}\frac{C}{E}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \tag{33}$$

It may be noted that the ground state of an electron in the Bohr model includes the energy of an orbital velocity and is defined by the value $n_2 = 1$, whereas in the present model the ground state of an electron occurs at a radius containing a larger number of electron wavelengths. The Bohr radius at the ground state is $a_0 = 5.29177.10^{-11}$ m and the number of Compton electron wavelengths in a circumference of this radius is $\frac{2\pi a_0}{\Lambda_c} = \frac{1}{\alpha} \approx 137$. If in the present model the number of Compton wavelengths in a circumference at the Bohr radius is assumed to be $137n_2 \approx n_2/\alpha$ where $n_2 = 1$ then from Eq.(33)

$$\frac{1}{\lambda} = \frac{\pi^2\alpha^4}{2\Lambda_c^3}\frac{C}{E}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

and equating this to Bohr's formula gives

$$\frac{\pi^2\alpha^4}{2\Lambda_c^3}\frac{C}{E} = R = \frac{\alpha^2}{2\Lambda_c} \quad \text{from which} \quad \frac{C}{E} = \frac{\Lambda_c^2}{\pi^2\alpha^2} \tag{34}$$

With this value of C/E, the formula derived from the alternative model is consistent with the emission spectrum of the hydrogen atom.

8. The hydrogen atom

Some parameters of the alternative model of a hydrogen atom can be estimated as follows.

Eq.(34) gives
$$\frac{C}{E} = \frac{\Lambda_c^2}{\pi^2\alpha^2} = \left(\frac{h}{\pi\alpha m_E c}\right)^2 = 1.120115.10^{-20}\ \text{m}^2 \tag{35}$$

If an electron wave is represented as a rotating stress pattern as proposed, then by analogy with fluid flow (and with reference to Kelvin's vortex atom) it might be expected that the rotating pattern takes the form of a free vortex, in which case the rotational velocity would be inversely proportional to the toroidal radius, i.e. $v_a = K_a/a$ where K_a is a constant and a is both the amplitude of vibration and the toroidal radius. The representative angular velocity of electron rotation is then $\omega = v_a/a = K_a/a^2$ and from Eq.(27)

$$T_1 - T_2 = \frac{1}{2}m_E\left(v_{a1}^2 - v_{a2}^2\right) = \frac{1}{2}m_E\left(\frac{K_a^2}{a_1^2} - \frac{K_a^2}{a_2^2}\right)$$

or
$$T_1 - T_2 = \frac{1}{2}K_a m_E\left(\omega_1 - \omega_2\right) = K_a\pi m_E\left(f_1 - f_2\right) \tag{36}$$

where f denotes a representative frequency of rotation. Eq.(36) represents the difference between two electron energy levels which are both proportional to frequency. This suggests that the term $K_a\pi m_E$ can be equated to Planck's constant h, giving

$$T_1 - T_2 = h\left(f_1 - f_2\right) \tag{37}$$

From Eqs.(13),(15),(26) the relationship between the circumferential stress p_θ and the rotational velocity v_a at large radii in a hydrogen atom approximates to $p_\theta = \frac{E}{2}\frac{v_a^2}{c^2} = \frac{C}{2r^2}$,

from which
$$\frac{v_a}{c} = \frac{1}{r}\sqrt{\frac{C}{E}} = \frac{K_a}{ca} \tag{38}$$

From Eqs.(36),(37) $K_a = h/\pi m_E$ and from Eqs.(35),(38) $\frac{a}{r} = \frac{h}{\pi m_E c}\sqrt{\frac{E}{C}} = 7.29737.10^{-3}$

The ratio of the toroidal radius to the radial position of an electron wave in a proton stress pattern is therefore equal to the fine structure constant α for spectroscopic changes in the energy of the electron.

From Eqs.(24),(38) the radius of intrinsic electron rotation is

$$a = \frac{2h}{\sqrt{3}\pi m_E c} = 8.91797.10^{-13}\text{m} \tag{39}$$

From Eq.(39) the corresponding radius in a proton stress pattern is $r = \frac{a}{\alpha} = 1.22208.10^{-10}$ m. Assuming that this radius defines the position in a proton stress pattern at which $p_\theta = E/4 = U_S$, the strain energy of an electron wave given by Eq.(22) can be expressed in the form $S = 8p_\theta \frac{\Lambda}{2}\delta A\left\{\left(1-\frac{v_a^2}{c^2}\right)^{-1/2} - 1\right\}$ and at the velocity ratio $\frac{v_a}{c} = \frac{\sqrt{3}}{2}$ the circumferential stress associated with the presence of an electron wave is $8p_\theta$. It is assumed that this increase in stress due to the presence of an electron wave results in the transfer of the wave to a radius given by $8p_\theta = 2E = \frac{C}{2r^2}$ or $r = \frac{1}{2}\sqrt{\frac{C}{E}} = 5.29177.10^{-11}$ m. This value is equal to the Bohr radius a_0. The classical intrinsic angular momentum of an electron corresponding to the rotation of a mass m_E at a toroidal radius αa_0 and a circumferential velocity $v_a = \frac{\sqrt{3}}{2}c$ is

$$m_E v_a \alpha a_0 = m_E \frac{\sqrt{3}}{2} c \alpha a_0 = 9.13285.10^{-35} \text{ kg m}^2 \text{ s}^{-1} \tag{40}$$

This value is almost exactly equal to the quantum value of electron spin given by

$L_S = \frac{\sqrt{3}}{2}\frac{h}{2\pi}$ and leads to the further equality $h = 2\pi m_E c \alpha a_0$ kg m^2 s^{-1} (41)

This equality gives a physical interpretation of Planck's constant as an intrinsic angular momentum.

9. Black body radiation

Assuming that the radiation pressure in a spherical proton radiation pattern is given by Eq.(12), the extent of a combined stress and radiation pattern of this form is theoretically infinite. A black body enclosure will contain multiple patterns originating in the atoms which form the walls of the enclosure. Let Z be the number of protons in the nucleus of an atom. Eq.(10) gives the equilibrium condition for the single proton of a hydrogen atom and for an atomic nucleus which contains a number of protons the equilibrium equation is $r^2\frac{dp}{dr} + 2rp = bZp$. From Eq.(12) there are Z solutions of this equation having the form $p = \frac{C}{r^2}e^{-bZ/r}$. The strain energy density of circumferential filaments at a radial stress equal to the radiation pressure in a proton radiation pattern is, from Eqs.(13),(16)

$$U_S = \frac{p^2}{E} = \frac{C^2}{Er^4} e^{-2bZ/r} \tag{42}$$

where $r = \frac{n\Lambda}{\pi}$, giving $U_S = \frac{\pi^4 C^2}{En^4 \Lambda^4} e^{-2\pi bZ/n\Lambda}$. Each solution corresponds to an atom having a particular atomic number. Eq.(37) shows that the energy of electrons can be expressed in the same form as the energy of photons, i.e. as proportional to frequency. It is suggested that the energy in a black body is equipartitioned between the photons radiated from an atom and the electrons in the atom, in which case $\Lambda = \lambda$ and the emitted radiation can be represented by the strain energy density (at the highest electron energy level)

$$U_S = \frac{\pi^4 C^2}{E\lambda^4} e^{-2\pi bZ/\lambda} \tag{43}$$

where the elastic modulus at a lower temperature than that of proton formation is assumed to be applicable to both thermal and spectroscopic radiant emission. Every element of internal surface area in a black body enclosure will contain many atoms of differing atomic number, and the radiation originating in these areas will be the sum of the radiation corresponding to all these atomic numbers, giving

$$U_S = \frac{\pi^4 C^2}{E\lambda^4} \left\{ e^{-2\pi b/\lambda} + e^{-4\pi b/\lambda} + e^{-6\pi b/\lambda} + ...e^{-2\pi bZ/\lambda} \right\} \tag{44}$$

The strain energy density given by this equation is a finite series (limited by the maximum value of Z) but is otherwise similar in form to the radiation energy density derived from Planck's formula and given by Eq.(4). This suggests that the emission of both spectroscopic and thermal radiation can be explained by the concept of proton stress patterns. It may be noted that the value of C^2 / E in the above equation is a constant which is common to all atoms and does not depend on black body temperature.

10. The nature of a proton stress pattern

The observations made in section 4 and comparison of Eqs.(4),(44) suggest that although solutions of the equilibrium equation depend on radiation energy density, the alternative explanation of Planck's formula and the nature of protons requires the representation of radiation patterns as spherical stress patterns in which radial radiation pressure is equated to radial stress. Comparing Eqs.(4),(44) enables values of the constant terms in Eq.(44) to be estimated as follows. Assuming that the strain energy density of Eq.(44) is equal to the radiation energy density of Eq.(4) then $A = 4\pi^4 \frac{C^2}{E} = 8\pi hc$

Therefore
$$\frac{C^2}{E} = \frac{2hc}{\pi^3} \tag{45}$$

and
$$B = 2\pi b = \frac{hc}{kT} \quad \text{therefore} \quad b = \frac{hc}{2\pi kT} \tag{46}$$

From Eqs.(35),(45) $C = \frac{2hc}{1.120115.10^{-20}\pi^3} = 1.14392.10^{-6}$ Nm^2

and $E = 1.02125.10^{14}$ N m^{-2}

The strain energy density corresponding to the stress pattern of a proton given by Eq.(12) is

$U_S = \frac{p^2}{E} = \frac{C^2}{Er^4} e^{-2b/r}$. The mass energy of a proton given by Eq.(7) is

$$mc^2 = 4\pi \int_0^\infty U_S r^2 dr = 4\pi \frac{C^2}{E} \int_0^\infty e^{-2b/r} \frac{dr}{r^2} \quad \text{or} \quad mc^2 = \frac{2\pi C^2}{bE} \left[e^{-2b/r} \right]_0^\infty = \frac{2\pi C^2}{bE}$$

From this and Eqs.(45),(46) $mc^2 = \frac{8kT}{\pi}$ and the estimated temperature of proton formation is $T = \frac{\pi mc^2}{8k} = 4.2758.10^{12}$ K. This temperature approximates to the value given by the standard model of cosmology. Having assumed that the force which forms a radiation pattern is electrostatic, Eqs.(11),(46) give $b = 3\sigma Gm / c^2 = \frac{hc}{2\pi kT}$ and using the estimated value of the temperature of proton formation, the ratio of electrostatic and gravitational force between the centre of a proton radiation pattern and an element of the pattern is

$\sigma = \frac{hc^3}{6\pi GmkT} = 1.4372.10^{38}$. For comparison with this value, the ratio of the forces between the proton and the electron of a hydrogen atom is $\sigma = 2.2687.10^{39}$. From Eq.(8) the electrostatic force between the centre of a proton radiation pattern and an element of unit mass at a distance r from the centre is $F = \frac{4\pi\sigma G}{c^2 r^2} \int_0^r U r^2 dr$ and equating radiation energy density to strain energy density,

$$F = \frac{4\pi\sigma G}{c^2 r^2} \frac{C^2}{E} \int_0^r e^{-2b/r} \frac{dr}{r^2} = \frac{4\pi\sigma G}{c^2 r^2} \frac{C^2}{E} \left[\frac{1}{2b} e^{-2b/r} \right]_0^r = \frac{2\pi\sigma G}{c^2 r^2} \frac{C^2}{bE} e^{-2b/r} \quad \text{where} \quad \frac{C^2}{bE} = \frac{mc^2}{2\pi}$$

and substituting this in the preceding equation gives $F = \frac{\sigma Gm}{r^2} e^{-2b/r}$ (47)

where $b = 3\sigma Gm / c^2 = 5.3555.10^{-16}$ m. The approximate force per unit mass in a proton radiation pattern (as a mechanical analogue of electrostatic force) is shown in the following figure, compared with the charge radius of a proton

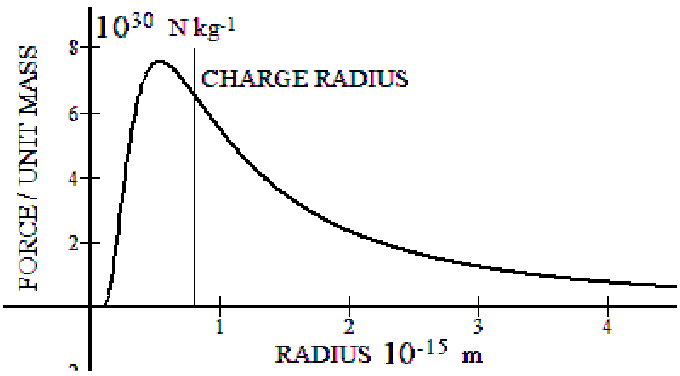


Figure 2 The radial force of attraction in a proton radiation pattern

Using the value of C and the value of $b = 3\sigma Gm / c^2 = 5.3554.10^{-16}$ m in Eq.(12) gives the radial radiation pressure and stress in a proton stress pattern shown in the following figure.

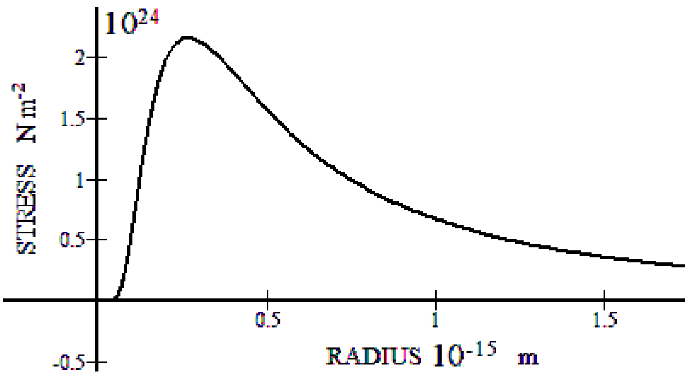


Figure 3 Radial pressure and stress in a proton stress pattern

It is assumed that the mass of a proton originated in the formation of proton constituents at a temperature of the order of 1.10^{18} K in the early universe, followed by the formation of protons at a temperature of $4.2758.10^{12}$ K. From section 4 the elastic modulus is proportional to radiation energy density, which from the Stefan-Boltzmann law is proportional to the fourth power of temperature. The elastic modulus at the higher temperature is therefore $E_P = E\left(\dfrac{1.10^{18}}{4.2758.10^{12}}\right)^4 = 3.0554.10^{35}\,\text{Nm}^2$ .The maximum elastic direct strain in a proton stress pattern is given by the maximum value of $\dfrac{2p_\theta}{E_P} = 2\times\dfrac{2.158.10^{24}}{3.0554.10^{35}} = 1.4126.10^{-11}$

It is possible that gravitational and other forces between patterns such as these can be accounted for by the superposition of stresses.

11. Dark matter

It is assumed that the constant of integration in Eq.(4) represents a background level of energy density and mass and that the formation of proton constituents, protons and atomic nuclei occurred at progressively lower values of temperature and energy density. In section 6 of the present article the velocity of light is associated with a strain energy density of $U_S = 4p_\theta^2 / E = E/4$. If this is the value of background energy density at the temperature of formation of primordial hydrogen nuclei and if this temperature is assumed to be $1.5.10^6$ K then at the present temperature of cosmic microwave background radiation the strain energy density is $U_S = \dfrac{E}{4}\left(\dfrac{2.725}{1.5.10^6}\right)^4 = 2.78.10^{-10}$ Nm^{-2} and the corresponding background mass density is

$$\rho = \frac{U_S}{c^2} = 3.1.10^{-27} \text{ kg m}^{-3}$$

This level of mass density appears to be consistent with the density of dark matter.

PART 2. THE FORCES BETWEEN PROTONS

1. Introduction

The work described in part one suggests that protons may be represented as spherical stress patterns in an infinite elastic medium. If two identical spherical stress patterns are assumed to exist in such a medium then at infinite separation the total strain energy of the two patterns is twice that of a single pattern. As the distance between the two patterns is reduced the stresses in the adjacent patterns are superimposed upon each other and at every point in the medium the strain energy becomes proportional to the square of the sum of two sets of stresses. When the centres of the patterns are coincident the strain energy at every point is proportional to the square of the sum of two equal stresses. The total strain energy is therefore equal to four times the strain energy of a single pattern.

This suggests that if the stress patterns are representative of protons then the superposition of two stress patterns may be representative of the formation of a helium nucleus having two protons and two neutrons.

2. The electrostatic force between protons

Eq.(47) in part one suggests that the forces between two proton stress patterns in an infinite elastic medium may be represented in a form similar to that of the stresses in the patterns. Let the electrostatic force of repulsion between two proton stress patterns be represented by an equation of the form

$$F_c = \frac{\sigma G m_p^2}{s^2} e^{-2b/s} \tag{1}$$

where s is the separation of the two centres, G is the gravitational constant, m_p is the mass of a proton, $\sigma = 2.2687.10^{39}$ is the ratio of electrostatic force to gravitational force at a large separation and $b = 5.3555.10^{-16}$ m is a constant. The separation s is zero at the point where the centres of the patterns are coincident. The potential energy generated by an external force $F = -F_c$ which reduces the separation from infinity to a distance s is then

$$E_P = -\int_\infty^s F_C ds = -\sigma G m_p^2 \int_\infty^s \frac{e^{-2b/s}}{s^2} ds = -\sigma G m_p^2 \left[\frac{e^{-2b/s}}{2b} \right]_\infty^s = \frac{\sigma G m_p^2}{2b}\left(1 - e^{-2b/s}\right) \tag{2}$$

From Eqs.(1) and (2)

$$F_c = -\frac{dE_P}{ds} \tag{3}$$

3. The formation of a helium nucleus

The sequence of events which leads to the formation of a helium nucleus is assumed to be as follows. Let one of two protons be fixed in position and the distance between the centres of the two protons be reduced by an external force on the second proton, which acts against the force of electrostatic repulsion and produces a potential energy of the form given by Eq. (2). Let the formation of two neutrons begin when this potential energy is equal to the mass energy of two neutrons plus a fusion energy release of 4.10^{-12} J , ie. when at $s = a$

$$E_P = \frac{\sigma G m_p^2}{2b}\left(1 - e^{-2b/a}\right) = 2m_n c^2 + 4.10^{-12} \tag{4}$$

From the above equation the value of the separation a is $0.7267.10^{-15}$ m.

Let the external force be removed and the fusion energy released at this separation, following which the distance between the protons is increased by electrostatic repulsion.

From Eq, (18) in part one the mass energy in a neutron stress pattern from a radius r to infinite radius is $m_n c^2 = 4\pi \frac{m_n}{m_p} \frac{C^2}{E} \int_r^\infty e^{-2b/r} \frac{dr}{r^2}$ where m_n and m_p are the masses of a neutron and a proton respectively, c is the velocity of light and the constants derived in part one are $C = 1.14392.10^{-6}$ Nm^2 , $E = 1.02125.10^{14}$ Nm^{-2} and $b = 5.3555.10^{-16}$ m.

From this
$$m_n c^2 = 4\pi \frac{C^2 m_n}{E m_p}\left[\frac{e^{-2b/r}}{2b}\right]_r^\infty = \frac{2\pi C^2 m_n}{E b m_p}\left(1 - e^{-2b/r}\right) \tag{5}$$

Eq.(5) is similar to Eq.(2), which is consistent with the conversion of the potential energy generated by an external force into the mass energy of two neutrons. It is assumed that this conversion begins at the separation $s = a$ and is continued as the separation is increased by electrostatic repulsion. In this case the radius in Eq.(5) becomes $r = s - a$ and for the formation of two neutrons Eq.(5) becomes

$$2m_n c^2 = \frac{4\pi C^2 m_n}{E b m_p}\left(1 - e^{-2b/(s-a)}\right) \tag{6}$$

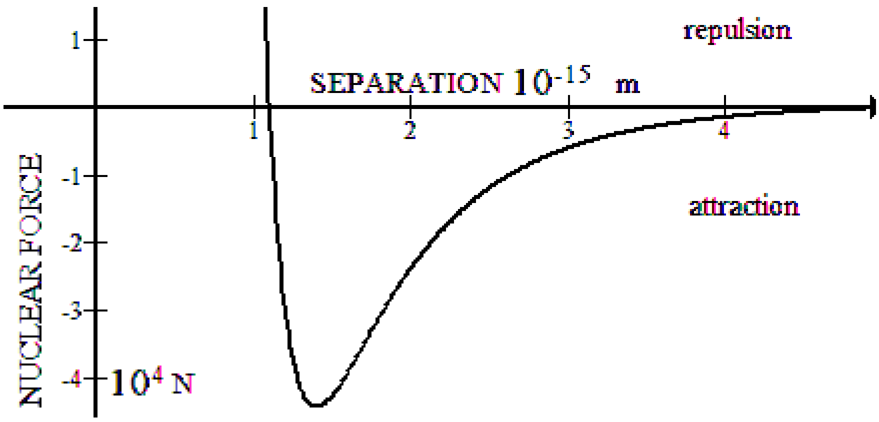
From Eq.(3) the mass energy given by Eq.(6) may be associated with a force

$$F_m = -\frac{4\pi C^2 m_n}{E b m_p}\frac{d}{ds}\left(1 - e^{-2b/(s-a)}\right) = \frac{8\pi C^2 m_n}{E m_p (s-a)^2} e^{-2b/(s-a)} \tag{7}$$

From Eqs.(1) and (7) the force remaining after the formation of two neutrons is therefore

$$F = F_c - F_m = \frac{\sigma G m_p^2}{s^2} e^{-2b/s} - \frac{8\pi C^2 m_n}{E m_p (s-a)^2} e^{-2b/(s-a)} \tag{8}$$

The form of the nuclear force given by Eq.(4) and Eq(8) is shown in the following figure.



Eq.(8) shows that the nuclear force reverts to a force of repulsion at a separation of $s = 5.10^{-15}$ m and at large separations decreases according to an inverse square law.

4. Conclusions

The electrostatic force F_c between protons which results in the nuclear force shown in the above figure is a modified form of the Coulomb force. At atomic dimensions the force F_c and the Coulomb force are effectively congruent but the forces diverge at nuclear dimensions and the force F_c has a limiting peak value. In the proposed model of a helium nucleus the nuclear force is a further modification of the Coulomb force between protons, which results from the conversion of potential energy to the mass of two neutrons. The separation at which this conversion begins is $s = a = 0.72362.10^{-15}$ m following which a position of stable equilibrium is created where the nuclear force curve crosses the axis of separation at a value $s = 1.1.10^{-15}$ m. It is assumed that following the formation of two neutrons, all four nucleons are returned to this position by the nuclear force of attraction.

PART 3. PROTONS, NEUTRONS, STARS AND THE RED SHIFT

1. Introduction

In parts one and two, protons are represented as spherical stress patterns of infinite extent. The possible differences between the stress patterns of protons and neutrons are described in this part and are shown to lead to an alternative explanation of the red shift of the light from distant stars.

2. The stress patterns of protons and neutrons

In part one it is assumed that the circumferential stress in a proton stress pattern is tensile, which allows the presence of transverse waves and electrons in circumferential filaments. The radial stress is in this case compressive, which is not compatible with radial transverse waves. Since there are two forms of spherical stress pattern which differ in the sign of the stresses, the circumferential stress in the second form is compressive and not compatible with electron waves. This form is therefore assumed to represent neutrons in which the radial stress is tensile, allowing the presence of radial transverse waves.

3. The stress pattern of a neutron

In a proton stress pattern the radial stress is $p_r = \frac{C}{r^2} e^{-b/r}$ where r is the radius to a point in the pattern, $C = 1.14392.10^{-6}$ Nm^2 and $b = 0.53555.10^{-15}$ m. From Eq.(18) in part one the variation of mass with radius in a proton stress pattern is given by $m_p = \frac{2\pi C^2}{bEc^2} e^{-2b/r}$ where $E = 1.02125.10^{14}$ giving $m_p = 1.6726.10^{-27} e^{-2b/r} = M_p e^{-2b/r}$ where M_p is the total mass of a proton. The corresponding equation for a neutron stress pattern is

$$m_n = M_n e^{-2b/r} = 1.6749.10^{-27} e^{-2b/r} \qquad (1)$$

This relationship between mass and radius is shown in the following figure.

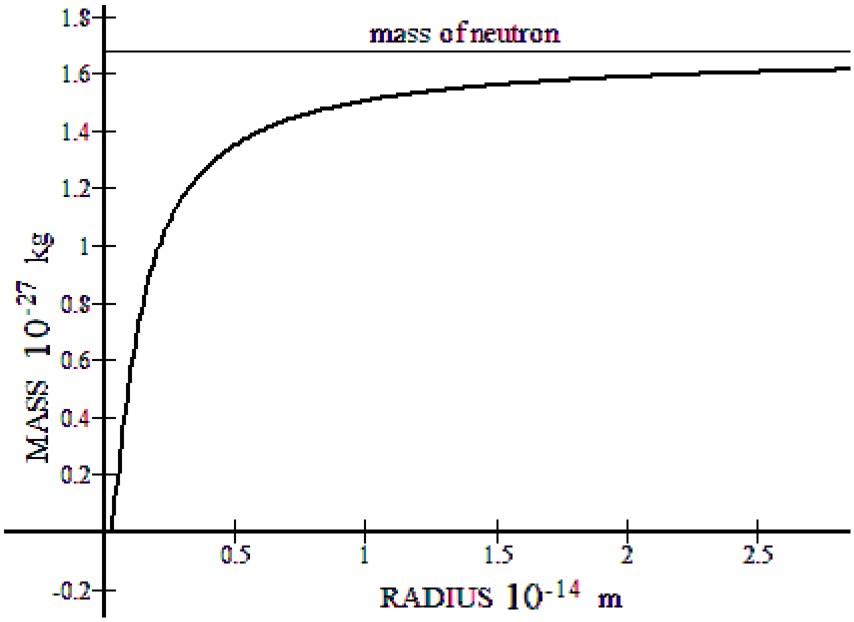


Figure 1

The density in a spherical stress pattern is given by Eq.(17) in part one as $\rho = \frac{p_r^2}{Ec^2}$. From Eq.(1) the differential $\frac{dm_n}{dr} = \frac{2M_n b}{r^2} e^{-2b/r} = \frac{d}{dr} 4\pi \int \rho r^2 dr = 4\pi\rho r^2$

which gives an alternative form of the variable density in a neutron stress pattern as

$$\rho = \frac{p_r^2}{Ec^2} = \frac{M_n b}{2\pi r^4} e^{-2b/r} \qquad (2)$$

The following figure shows the relationship between density and radius in a neutron stress pattern.

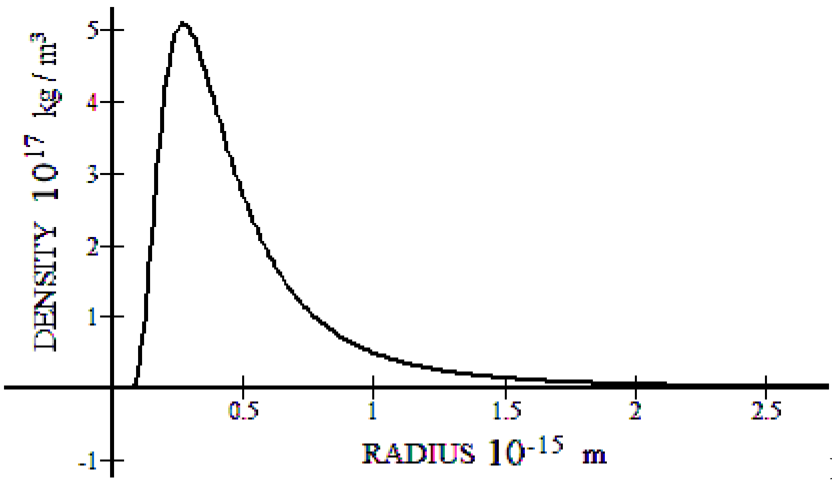


Figure 2

4. The refraction of light

The velocity of light is changed by refraction when passing from one medium to another. Based on the refractive indices of transparent materials it is assumed that the velocity of light is related to the density of the medium through which it is transmitted (see Appendix 1).

From Eq.(2) $$p_r^2 = \frac{M_n b E c^2}{2\pi r^4} e^{-2b/r} \quad \text{giving} \quad p_r = \frac{c e^{-b/r}}{r^2} \left(\frac{M_n b E}{2\pi} \right)^{1/2} \qquad (3)$$

In the spherical stress pattern of a neutron the density is variable and the radial wave velocity is given by $v = c\sqrt{\dfrac{E}{2p_r}}$. Substituting for the stress p_r from Eq.(3) gives

$$v = r e^{b/2r} \sqrt{\frac{c}{2}} \left(\frac{\pi E}{2M_n b} \right)^{1/4} = 1.4158.10^{18} r e^{b/2r} \qquad (4)$$

Assuming that the velocity given by the above equation is the velocity of light as a function of density, the following figure shows the variation of the radial velocity of light with respect to radius in a neutron stress pattern.

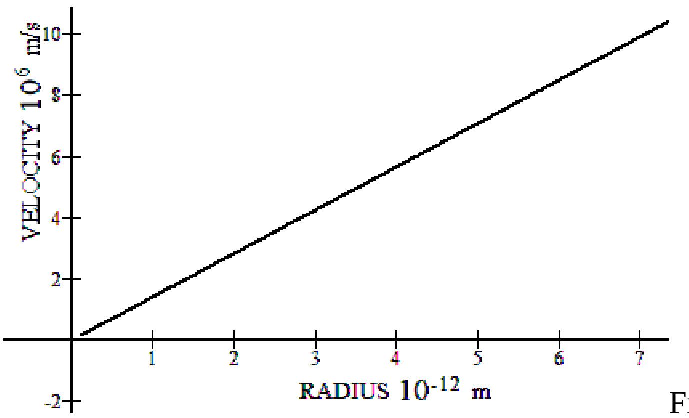


Figure 3

5. The red shift

In a proton stress pattern the radial stress produced by electrostatic force is in equilibrium with radial radiation pressure. Similarly, in a star such as the sun the radial pressure produced by the force of gravity is in equilibrium with radial radiation and gas pressure. Assuming that the sun can be represented as a spherical radiation and stress pattern in which mass is equated to strain energy, let the radial velocity of light in this pattern be similar to that given by Eq.4 and shown in Fig.(3). Then

$$v = re^{b/2r}\sqrt{\frac{c}{2}}\left(\frac{\pi E_S}{2M_S b}\right)^{1/4} \tag{5}$$

In this equation $M_S = 1.988.10^{30}$ kg is the mass of the sun and E_S is the elastic modulus corresponding to the temperature at which the sun was formed, ie. the temperature of the cosmic background radiation $T = 2.725$K. The formation temperature of a neutron stress pattern is $4.2758.10^{12}$ K and the elastic modulus at this temperature is $E = 1.02125.10^{14}$ N / m^2. From part one the elastic modulus is proportional to the fourth power of temperature therefore

$$E_S = E\left(\frac{2.725}{4.2758.10^{12}}\right)^4 = 1.685.10^{-35}\ \mathrm{N/m^2} \tag{6}$$

Using the above values of M_S and E_S in Eq.(5) together with an assumed value of the constant b of 1.10^{22}m gives the velocity of light at cosmic distances in a solar stress pattern. The following figure shows the velocity given by Eq.(5) compared with that of Hubble's law.

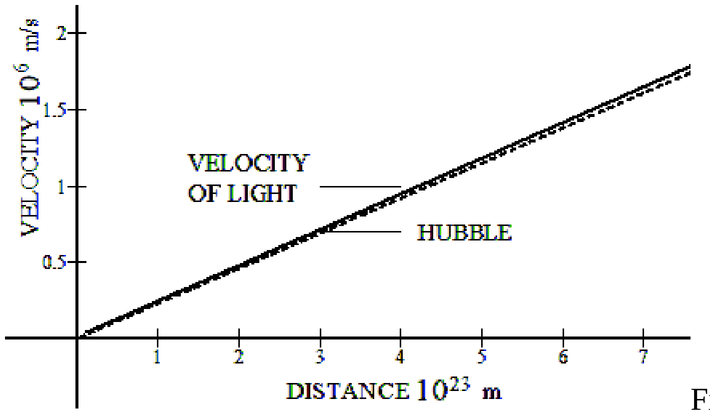


Figure 4

The above characteristic shows that light originating in a stress pattern of the sun (or in the the patterns of stars of the same mass as the sun) travels to the earth through a medium of decreasing density and at increasing velocity and wavelength. This increase in velocity is compatible with Hubble's law and varies with the distance of a star from the earth, but does not depend on motion of the sun and the stars.

Eq.(5) shows that the velocity characteristic of a star is a function of the mass of the star. The following figure includes the predicted velocity characteristics of stars of minimum and maximum mass.

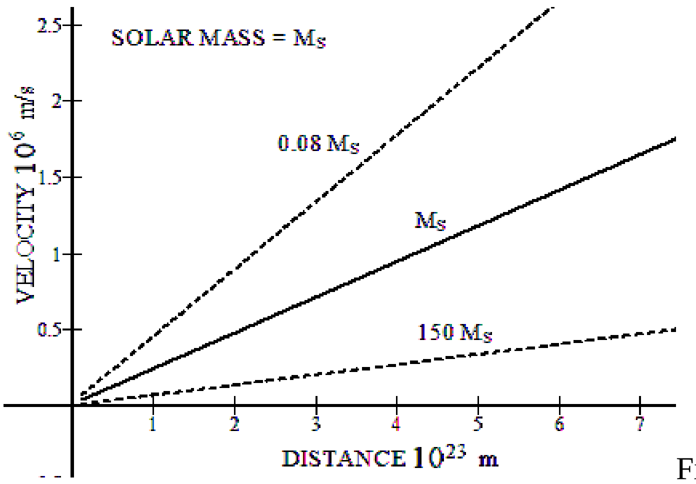


Figure 5

The above figure shows that the velocity of light emitted from a star decreases with the mass of the star and for stars of much greater mass than $150M_S$ there may be no light emitted. Such a star would then have the characteristic of a black hole.

6. A stress pattern of the sun

Substituting the values of the mass M_S and the constant b in Eqs.(1) and (2) gives the solar stress pattern characteristics of mass and density at cosmic distances as

$$m_s = M_S e^{-2b/r} \tag{7}$$

and

$$\rho_s = \frac{M_S b}{2\pi r^4} e^{-2b/r} \tag{8}$$

These characteristics are shown in the following figures.

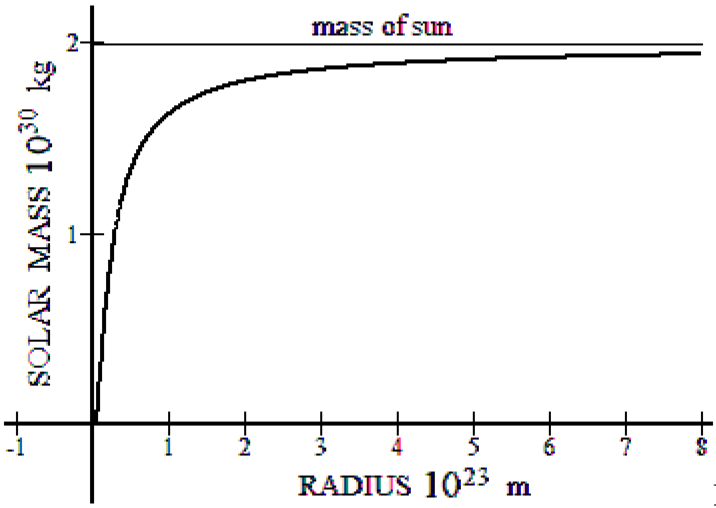


Figure 6

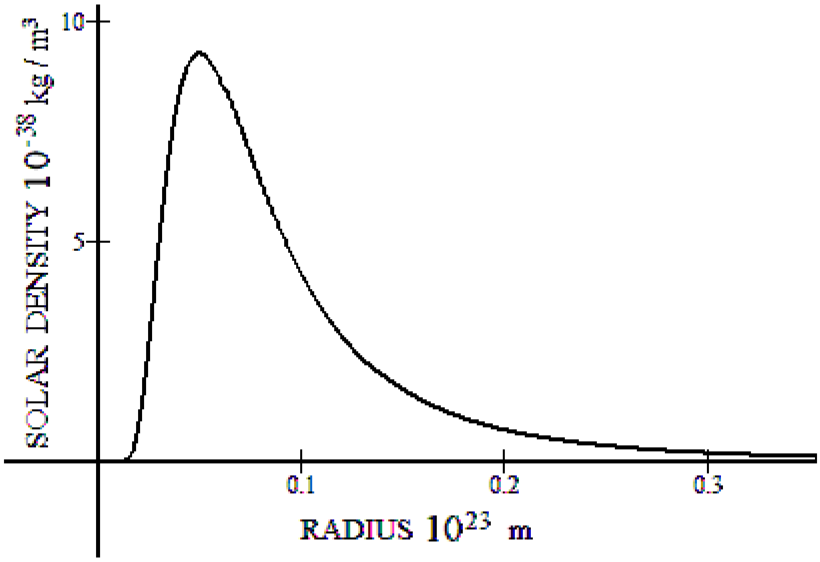


Figure 7

It was shown in part one that the formation of a hydrogen nucleus is associated with a background mass density which is consistent with that of dark matter. It has been assumed that the sun and other stars can be represented as spherical stress patterns of a form similar to the stress pattern of a neutron. If the formation of a star is also associated with a constant background mass density then at great distance from a star the mass density in the stress pattern of the star approaches zero and the absolute mass density becomes equal to the background density. The temperature at this condition is that of the cosmic microwave background and the elastic modulus at this temperature is given by Eq.(6). Assuming that the velocity of light in this background is $v = c = c\sqrt{\frac{E_S}{2p}}$ where p is a uniform background stress, then $p = \frac{E_S}{2} = 8.425.10^{-36}\ \mathrm{N/m^2}$ and the corresponding universal background mass density is

$$\rho = \frac{p^2}{E_S c^2} = 4.687.10^{-53}\ \mathrm{kg/m^3}$$

This suggests that the velocities shown in Fig.(5) are limited to the universal constant $v = c$ at larger astronomical distances. It may be noted that spherical stress patterns can not be formed in the absence of radiation and that planets such as the earth have no external stress patterns.

7 . Conclusion

The submitted proposition offers an alternative to Hubble's law which can be tested by application to multiple stars of different masses.

Nomenclature

A, a	cross-sectional area, m^2;	r	radius, m;
a	wave amplitude or distance, m;	S	strain energy, J;
a_0	Bohr radius, m;	s	circumferential or linear distance, m;

c	velocity of light, m s^{-1};	T	tensile force, N; kinetic energy, J ;
E , E_P	modulus of elasticity, N m^{-2};		absolute temperature, K;
F	force, N	t	time, s;
f	frequency, cycles / s;	U	radiant energy density, J;
G	gravitational constant, Nm^2 kg^{-2};	U_S	strain energy density, J;
h	Planck's constant, J s;	v	wave velocity, m s^{-1};
k	Boltzmann's constant, J K^{-1};	v_a	transverse velocity, m s^{-1};
L_S	electron spin, kg m^2 s^{-1};	v_r	orbital velocity, m s^{-1};
l	length, m;	W	radiation energy, J;
m	mass, kg;	y	transverse wave deflection, m;
m_E	rest mass of electron, kg;	Z	number of protons in nucleus;
M_p	mass of a proton. kg;		
M_n	mass of a neutron, kg;		
M_s	mass of the sun, kg;		
N	number of wavelengths;	α	fine structure constant;
n	number defining Bohr energy level;	Λ	circumferential wavelength, m;
p	pressure or stress, N m^{-2} ;	Λ_c	Compton wavelength, m;
p_r	radial stress, N m^{-2} ;	μ	mass per unit length, kg m^{-1};
p_θ	circumferential stress, N m^{-2}	ρ	mass density, kg m^{-3};
q	shear stress, N m^{-2};	σ	ratio of forces
R	Rydberg's constant;	ψ	shear strain

APPENDIX 1

THE VELOCITY OF LIGHT AS A FUNCTION OF DENSITY

1. Introduction

It has been shown in Part 3 that if the velocity of light in an ideal elastic medium is a function of the density of the medium then an alternative explanation of the red shift can be found. Some evidence to support this assumption is available in the data for transparent materials.

2. The velocity of light in materials

It can be shown that there is an approximate relationship between the velocity of light in transparent materials and their density, having the form shown in the following figure.

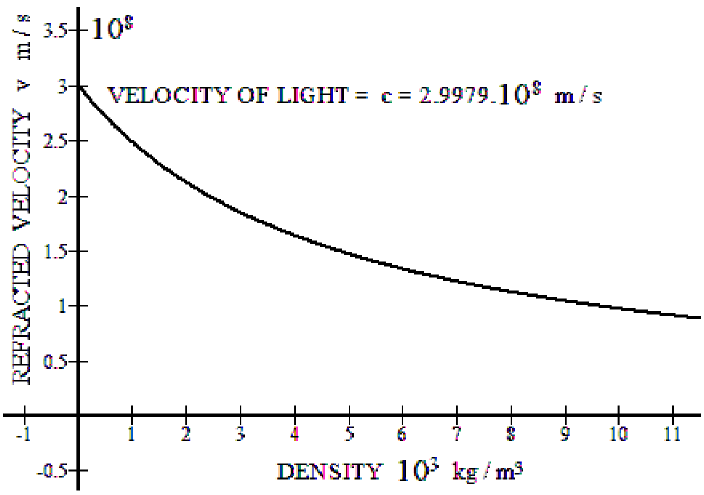


Figure 1

3. Wave velocity versus density in the sun

From section 4. in PART 3 the radial wave velocity in a spherical stress pattern of the sun is $v = c\sqrt{\dfrac{E_S}{2p_r}}$ where $E_S = 1.685.10^{-35}$ N / m^2 and p_r is the radial stress in the pattern.

From Eq. (17) in PART 1 the density is $\rho = \dfrac{p_r^2}{Ec^2}$, giving $p_r = c\sqrt{E\rho}$ and by substitution $v = \sqrt{\dfrac{c}{2}}\left(\dfrac{E_S}{\rho}\right)^{1/4}$. The form of this equation results in infinite wave velocity at zero density, but Fig. (2) indicates that in the case of transparent materials the velocity is limited to the velocity of light $v = c$, which is the wave velocity corresponding to the universal background density $\rho_B = 4.687.10^{-53}$ kg / m^3 (from section 6. in PART 3). With this limitation the wave velocity in the stress pattern of the sun is given by

$$v = \sqrt{\frac{c}{2}}\left(\frac{E_S}{\rho + \rho_B}\right)^{1/4} \qquad (1)$$

The form of this function is shown ithe following figure.

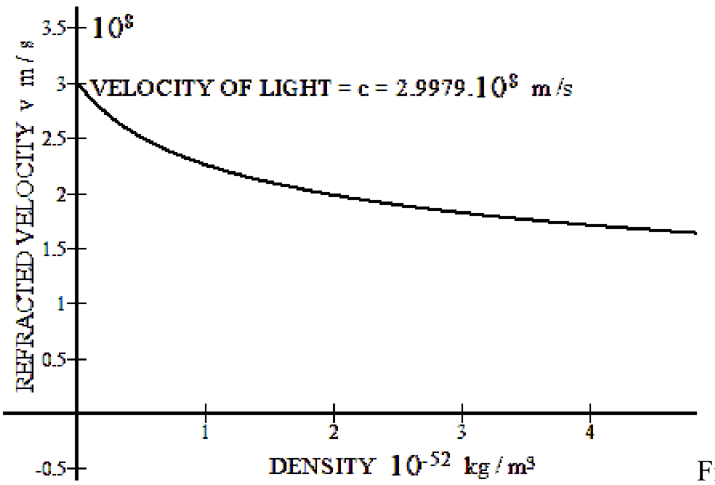


Figure 2

4..Conclusion

The similarity between Fig.(1) and Fig.(2) exists even though the two conditions are at opposite extremes of density and offers support to the assumption that the velocity of light is a function of the density of the medium through which it is transmittted.