An explanation for the cosmological redshift

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Abstract: A new theoretical model is presented which accounts for the cosmological redshift in a static universe. In this model the photon is viewed as an electromagnetic wave whose electric field component causes oscillations in deep space free electrons which then reradiate energy from the photon, causing a redshift. The predicted redshift coincides with the data of the Hubble diagram. The predicted redshift expression allows for the first time distance measurements to the furthest observable objects, without having to rely on their apparent magnitudes which may be subject to cosmic dust. This new theoretical model is not the same as, and is fundamentally different from, Compton scattering, and therefore avoids any problems associated with Compton scattering such as the blurring of images. © *2010 Physics Essays Publication*. [DOI: 10.4006/1.3397803]

Résumé: Un nouveau modèle théorique est présenté qui explique le décalage vers le rouge cosmologique dans un univers statique. Selon ce modèle le photon est visualisé comme une onde électromagnétique, dont la composante électrique cause des oscillations dans les électrons libres dans l'espace intergalactique qui ensuite diffusent l'énergie du photon, causant un décalage vers le rouge. Le décalage vers le rouge prédit coïncide avec les données du diagramme de Hubble. L'expression prédite du décalage vers le rouge permet pour la première fois la mesure des distances aux objets les plus lointains observables, sans devoir tenir compte de leur magnitude apparente qui peut être sujette à la poussière cosmique. Ce nouveau modèle théorique n'est pas le même, et il est fondamentalement différent, de la diffusion Compton, et donc il évite tout problème associé à la diffusion Compton tel que le brouillage des images.

Key words: Cosmology; Cosmological Redshift; Cosmological Models; Supernovae; Cosmic Dust.

I. INTRODUCTION

Compton scattering has long been rejected as an explanation for the cosmological redshift because in this particle-particle interaction, photons are scattered into various angles at various frequencies, resulting in a blurring of images.[1] Numerous other mechanisms have been attempted to explain the cosmological redshift, such as an energy loss of the photon when traversing a radiation field,[2] an inelastic scattering by gaseous atoms and molecules,[3] or a dispersive-extinction effect by the space medium.[4,5] Previously unconsidered by the principle of complementarity, a photon may also be viewed as a wave, interacting with intergalactic free electrons in a wave-particle fashion.

It is reasonable to assume that although very short wavelength photons (gamma rays) can interact with electrons in a particle-particle fashion (Compton scattering), photons of longer wavelengths than those of gamma rays could interact with electrons in a wave-particle fashion, the electron reacting to the photon's electric field. Being that a wavelength of visible light is eight orders of magnitude larger than an electron, a visible wavelength photon should pass directly over an electron with unchanging direction and with negligible blurring of images. This would circumvent Zwicky's above mentioned historical objection to Compton scattering over blurring of images and satisfy the consideration that photons travel *without appreciable transverse deflection*.[6] Furthermore, any other objection to Compton scattering (particle-particle) as an explanation for the cosmological redshift is irrelevant to the thesis of this present article, which does not propose a Compton scattering explanation but rather a fundamentally different redshift mechanism based on an instead wave-particle interaction. The thesis of this present article is a theoretical prediction of a new mechanism, a new fashion in which a photon could interact with free electrons in deep space. This new theoretical model is supported by the calculations provided below, the predicted cosmological redshift coinciding with the data of the Hubble diagram.

A clear distinction is being drawn here between the case of extremely high frequency (gamma ray) Compton scattering (particle-particle) interactions, and the different manner in which photons of longer wavelengths than those of gamma rays may interact with free electrons in an instead wave-particle fashion. In the former case, the intensity (photon flux) of radiation is reduced as gamma ray photons are simply scattered out of a beam of gamma radiation. In the latter case, photons of longer wavelengths than those of gamma rays are seen as passing directly over the free electrons with therefore no change in a photon's forward direction. Easily visualized as an example, a very long radio wavelength photon which passes over a free electron will certainly cause a radio frequency oscillation in the electron, while the radio wavelength photon continues along in its original straight path. In this long wavelength case, the in-

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tensity (photon flux) of a beam of photons remains unchanged. What is, however, expected is a minuscule reduction in each incident photon's energy (a redshift) as the free electrons are encountered, as will be demonstrated below by calculation. This mode of interaction is expected to hold not only for radio frequencies but over the entire frequency range of observed spectral lines all the way into the x-ray regime.

A further distinction is drawn here between these two separate cases. In high frequency (gamma ray) Compton scattering, photons can experience a change in their frequency, but a strong unshifted component remains. In contrast, photons of longer wavelengths than those of gamma rays as observed in the spectral lines from stars do not exhibit both frequency shifted and unshifted light, rather these photons are seen as all interacting with deep space free electrons in a wave-particle fashion, where all photons are equally redshifted by the law of large numbers, each photon from a particular spectral line of a particular object encountering the same great number of free electrons in deep space.

As a note, in the situation of extremely dense radiation fields such as where very powerful lasers are used in laboratory Thomson scattering measurements of plasma densities, or in the extremely dense radiation fields in the interior of stars, a new interpretation of the manner is suggested here in which photons of longer wavelengths than those of gamma rays are actually interacting with free electrons. In these dense radiation fields, one has the impression that the powerful laboratory laser beam's photons can experience a change in their direction and be subtracted from the beam, as do gamma ray photons in Compton scattering. It is, however, suggested here that in these very dense radiation fields, the individual photons of longer wavelengths than those of gamma rays are not actually deflected from their straight line paths, rather the free electrons are so massively agitated by radiation that a free electron reradiates photons at the same frequency of the radiation field only after taking a tiny bit of energy from each and every photon that passes directly over the free electron. The incident laboratory laser beam would then have no reduction in its photon flux but rather simply a tiny reduction in the frequency of each incident photon. The cosmological redshift might therefore be testable using laboratory lasers, although conditions in dense radiation fields in laboratory plasmas are radically different from those in deep space.

II. ANALYSIS OF THE REDSHIFT MECHANISM

The following discussion analyzes by calculation the (wave-particle) fashion in which photons of longer wavelengths than those of gamma rays may interact with deep space free electrons, resulting in the redshifted spectral lines of astronomical objects.

A photon is an electromagnetic wave whose electric field component should cause an oscillation in any free electron over which passes the wave. The electron duly accelerated must reradiate energy at the expense of the wave. A free electron has been demonstrated by electromagnetic theory to have an effective area for reradiating the energy of an incident electromagnetic wave, the Thomson scattering cross section.[7] Applying Planck's relation ($E=hf$) that the energy of a quantum of electromagnetic energy be proportional to its frequency, one expects then that the frequency of the photon is lowered in proportion to this reduction in its energy, i.e., a redshift. Much more massive are ions whose effect is neglected.

From the point of view of electromagnetic wave theory, as a photon passes over a single free electron the electron is not displaced from its initial position but simply oscillates about its fixed position with the electric field of the wave, reradiating energy in a symmetric dipolar fashion, therefore not causing the wave to alter its forward direction. Note that in the calculation of the Thomson scattering cross section, the electron is taken as fixed in that the random velocities of free electrons are assumed small compared to the speed of light of the incident photon. Also in the calculation of the Thomson scattering cross section, the electron is taken as reacting only to the photon's electric field component, the electron's assumed subrelativistic velocity allowing one to neglect the magnetic component of the Lorentz force. Any effect of the electron's dipole moment is also neglected.

If now a photon, viewed as in itself an incident electromagnetic wave, traverses the rarefied deep space of the cosmos for billions of years, the photon's wavefront slowly and eventually encounters vast numbers of free electrons one at a time, resulting in a cumulative redshift which can be calculated. The following equation expresses a fractional decrease (dI/I) in a plane EM wave's energy flux I as the wave encounters an electron density n, where electrons have an effective cross-sectional area C, the well known standard value for the Thomson scattering cross section of electrons. The equation follows immediately from the definition of the Thomson scattering cross section, which is the effective area of the free electron to reradiate energy from an incident electromagnetic wave (the photon) whose direction remains unchanged.

$$dI/I = - Cndx. \tag{1}$$

We can now integrate this equation, the integral of the right hand side being the total cross-sectional area of all the electrons (per m^2 of incident wave) that the incident wave would be intercepting over a distance x. Completing the integration of both sides of the equation and then solving for I yield a standard exponential decay for I, the incident energy flux, over a distance x, where the exponential decay constant k has the value $(1/Cn)$.

$$I \sim \exp(- x/k). \tag{2}$$

Assuming for illustrative purposes, an average electron density of 100 e/m^3 in intergalactic space, the exponential distance scale k ($=1/Cn$) for the weakening (redshifting) photon calculates to be 16×10^9 light years. Dividing by the speed of light gives an exponential redshifting time scale of 16×10^9 years, which is approximately the hypothetical "age of the universe" according to the Big Bang theory. This provides a simple alternative explanation for the extremely redshifted edge of the visible universe, due to wave-particle scattering by free electrons, as opposed to the expansion hypothesis of the Big Bang theory.

Regarding the above assumption of an estimated 100 free electrons/m^3, note that any small uniform background of free electrons in deep space would have negligible effect on the observed dynamics of astronomical systems. Any higher or lower estimate for an average free electron density in deep space would, respectively, decrease or increase the above calculated redshifting distance scale. Estimated values for Hubble's constant have varied appreciably. By choosing a higher or lower figure for the average free electron density, one can precisely produce the same effect of any estimated value for Hubble's constant in that by either redshifting mechanism the linear distance versus redshift graphs for nearby measurable astronomical objects would coincide.

III. AGREEMENT WITH THE HUBBLE DIAGRAM

The precise coinciding of redshift graphs is quickly seen from the above exponential expression for the redshifting photon, where the photon's frequency f has the following dependence:

$$f \sim \exp(-Cnx). \tag{3}$$

For nearby astronomical objects, the frequency is therefore linear with distance.

$$f \sim (1 - Cnx). \tag{4}$$

Calculating redshift we then arrive immediately at the following equation:

$$z = \text{redshift} = Cnx. \tag{5}$$

The Hubble expression for redshift is also linear with distance and precisely coincides with the above linear expression for redshift when simply equating the proportionality constants.

$$Cn = H/(\text{speed of light}). \tag{6}$$

Taking one estimate of Hubble's constant to be the inverse of 13.7×10^9 years, the value of n is calculated to be 116 e/m^3, the average free electron density that produces a linear distance versus redshift behavior which precisely coincides with that from Hubble's constant.

The above calculation demonstrates how just a small amount of intergalactic free electrons can result in the cosmological redshift observed in the spectral lines of astronomical objects.

Note that the emergent spectrum originates at the star's surface, and the cosmological redshift begins to increase thereafter, as the photons pass over vast numbers of free electrons in deep space after billions of years of travel.

Further regarding the above assumption of approximately 100 e/m^3 in deep space, the average electron density in deep space has never been directly measured. The discovery of voids and supervoids in deep space make even more difficult the problem of directly measuring an effective average value for the density of electrons in deep space. The arguments presented in this present article are based on the implicit assumption that the electron density in deep space is homogeneous in space and time. Models of the Big Bang theory predict numbers for the mass density of the universe, but if one rejects the Big Bang theory and proposes alternative theories, the Big Bang based predictions for mass density are meaningless. The above determination of an average effective density of 116 e/m^3 is supported by the above calculation which shows precise agreement with the current value for Hubble's constant.

As for laboratory confirmation of my above proposed explanation for the cosmological redshift, to detect a redshift in the laboratory would be difficult because electron densities normally attained in laboratory plasmas are far too low. However, the effect does appear to exist over astronomical distances where vast numbers of free electrons are available.

IV. CALCULATION OF THE DISTANCES TO THE FURTHEST OBSERVABLE OBJECTS

One now returns to the above predicted redshifting frequency dependence which was expressed by the following:

$$f \sim \exp(-Cnx). \tag{7}$$

From this frequency dependence, the redshift of the weakening photon is then immediately calculated yielding the following general formula (redshift=fractional change in frequency) which holds out to the furthest cosmological distances.

$$z = \text{redshift} = \exp(Cnx) - 1. \tag{8}$$

This redshift formula is therefore independent of the observed brightness of an astronomical object. It is also independent of the photon's frequency, thereby admitting the same redshift measurement in any wavelength band of observed spectral lines. Linear at nearby distances in precise agreement with Hubble's data, as shown above, we now find that at great distances the redshift should increase exponentially.

Solving this expression for redshift one finds the following general equation for determining the distance x to cosmological objects based on their redshifts.

$$x = (1/Cn)\ln(\text{redshift} + 1). \tag{9}$$

At great distances, using the above calculated $n = 116$ free electrons/m^3 in deep space, one sees that for a redshift of 1.72, the distance of an astronomical object reduces to the following:

$$x = 1/Cn = (\text{speed of light})/H = 13.7 \times 10^9 \text{ light years}. \tag{10}$$

Type 1a supernovae with redshift of 1.72 should then be at a distance of 13.7×10^9 light years. Distant Type 1a supernovae are observed to be much dimmer than their redshifts would normally indicate, leading one to believe them to be further than 13.7×10^9 light years. However, the cumulative effect of cosmic dust at great distances is presumed to be responsible for their dimness and for their divergence from the linear Hubble relation at high redshifts.[8,9] Using distance modulus to calculate the distance of nearby astronomical objects is reliable, but at great distances absorption coefficients of cosmic dust make distance modulus measurements uncertain. The above exponential expression for redshift allows distance calculations for the furthest observed astronomical objects without needing any corrections for cosmic dust. The arrival of a single photon from a particular spectral line in principle allows the calculation of the distance to the furthest observable object. It matters not how many photons arrive, the above redshift expressions being independent of observed brightness. The above exponential expression for redshift circumvents the problem of dust extinction when measuring the furthest cosmological distances.

Observations of time dilation in supernova light curves are here regarded as inconclusive, such studies perhaps involving systematic errors in their interpretation or treatment of data, possibly in their sampling of intrinsically brighter supernovae at high redshifts while ignoring these dimming effects of cosmic dust. The surface brightness test is also regarded here as inconclusive in view of these heretofore neglected effects of cosmic dust at high redshifts.

V. FINAL COMMENTS

A new theoretical model has been presented here which accounts for the cosmological redshift in a static universe. This new theoretical redshift model is simpler than the hypothesis of expanding space as derived from the gravitational field equation. This new explanation for the cosmological redshift also provides a solution to Olbers' paradox, a photon slowly redshifting to frequencies not capable of stimulating the human eye.

This new non-Doppler explanation for the cosmological redshift also permits for the first time distance measurements to the furthest observable astronomical objects. Not only do these newly allowed distance measurements circumvent the problem of cosmic dust, they also are no longer subject to the question of the Big Bang's adjustable scale factors. Without the Big Bang theory comes a new postmodern cosmology where the universe is seen as presumably infinite spatially and temporally, which necessarily implies a new *dynamic equilibrium cosmology*.

It is suggested here that research is directed into identifying the processes which maintain this equilibrium, namely, processes whereby entropy must be recycled and starlight returns to matter, both these conditions possibly satisfied by deep space pair production processes. The cosmic microwave background should be reconsidered as due to the temperature of space as first calculated in 1896 by Nobel Prize winner Charles Édouard Guillaume.[10] Without the Big Bang theory, a symmetric universe with equal amounts of matter and antimatter can now be considered, evidenced in the cosmic gamma ray background radiation. A picture then emerges of matter-antimatter annihilation keeping an eternal universe churning, all matter unable to coalesce to any particular point. This then immediately offers a new direction of research into gamma ray bursts, quasars, blazars, and other extremely energetic objects, possibly explainable by various scenarios of matter-antimatter annihilation. This would avoid having to use the unphysical mathematical singularities inherent in the gravitational field equation, on which have been based models of astronomical black holes as well as the initial hypothetical Big Bang itself.

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