Some proposals for more experiments on light to understand the observations of 'Cosmological red-shift'

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Abstract: This paper reports result of an experiment performed by this author; and proposes more experiments based on 'wave' or 'particle' nature of light; so that it can help us to understand the observations of 'cosmological red-shift'. (i) While considering the propagation of light from a distant galaxy, the astrophysicists currently think that only the intensity of light gets reduced with distance. But as soon as we mathematically-describe the electric-field of light varying with distance, we have to write E (r, t) = A sin ($k\ r$) / r ; and we know that sin x / x is known as sink-function, and its Fourier-transform gives a wide-spectrum, whose spot-frequency is expected to vary with reduction of intensity due to the recession of galaxies; so I experimentally verified this possibility and confirmed that while reducing the amplitude of a wave, its frequency also gets shifted; depending upon the *rate of reduction of amplitude*; as reported here. (ii) Even if we treat light as a stream of 'photons', whose density goes on reducing with distance, then also we do expect a spectral-shift towards zero-frequency; as described here. (iii) The spherically-expanding-wave of light can also be viewed as an expanding-cavity-of-wave-guide; and the photon can travel only at close-to but slightly lesser speed than EM-waves; and the observed increase of wavelength of the extra-galactic-photon can be in accordance to the expression first proposed by Lord Rayleigh (iv) It may not be the hundred-percent correct assumption, that there is no reflected-power during the transmission of light through space, because the wave-impedance of the sphere containing the waves, keeps on changing with distance; expected to cause an input-output mismatch, possibly leading to some reflected power. It is proposed here that the observed 'cosmological-red-shift' may be partly due to these new 'propagation-property' of light.

Key Words: Point-source-of-light, Spherically-expanding-wave-front, Wave-guide-cavity, Wave-particle-duality

Introduction:

There was a time in the history of communication-engineering, when engineers could not think that changing just the amplitude of carrier-waves can change its frequency as well, and so amplitude-modulated-carrier causes a spread of spectrum, and requires much wider bandwidth than just a single-frequency. Similarly, while considering the propagation of star-light from a distant galaxy, the physicists currently think that only the intensity of light gets reduced with distance; but since according to the Big-Bang-Model, the galaxies are continuously moving away from us, and there is some *time-rate of reduction of intensity* at a given distance. So we expect some additional red-shift, proportional to the rate of reduction of intensity, in addition to the Doppler-shift.

Based on the 'particle' nature of light also, when we Fourier-transform a stream of point-particles, called 'photons', we get a spectral-shift towards zero-frequency, as the flux of photons reduces with distance.

Thirdly, the spherically-expanding-wave of light is comparable with an expanding-cavity-of-wave-guide, and a photon, being a 'particle', is likely to travel at close-to, but slightly-smaller-speed than EM-waves; and the expression first derived by

Lord Rayleigh indicates that there is a possibility of increase of wavelength of a wave with the increase of radius of the spherical cavity formed by the wave-front.

Fourthly, it may not be the hundred-percent correct assumption, that there is no reflected-power during the transmission of light through space, because the wave-impedance of the spherical-cavity keeps on changing with distance, continuously causing an input-output mismatch; leading to some reflected power.

Thus, this attempt proposes some more possibilities which should be taken into consideration, and needs experimental verification, while interpreting the 'cosmological-red-shift'.

2. An experiment showing that the process of reduction of 'amplitude' also causes a shift in frequency:

While considering the propagation of star-light from a distant galaxy, the physicists currently think that only the intensity of light gets reduced with distance. But since, according to the Big-Bang-Model the galaxies are continuously moving away from us; so there is some time-rate of change of intensity at every distance.

So, I connected *hp*'s high-stability signal-generator to *hp's* spectrum-analyzer and adjusted its frequency at 1 MHz, and out-put power +10 dBm; and adjusted the frequency-resolution of the spectrum-analyzer to 100Hz per c.m. Then I smoothly reduced the out-put-level from the generator and noticed the shift of frequency as shown in fig.1 below. Faster I reduced the amplitude, larger was the shift in frequency; that is the shift in frequency was proportional to the '*rate*' of reduction of the amplitude; and only during the process of reduction of the amplitude. When I increased the amplitude, the spectrum-analyzer showed a frequency-shift toward higher-frequency than 1 MHz.

This experiment can be repeated by taking a highly-stable single-frequency crystal-oscillator; and automated reduction of amplitude. And the display of spectrum-analyzer can be video-recorded.

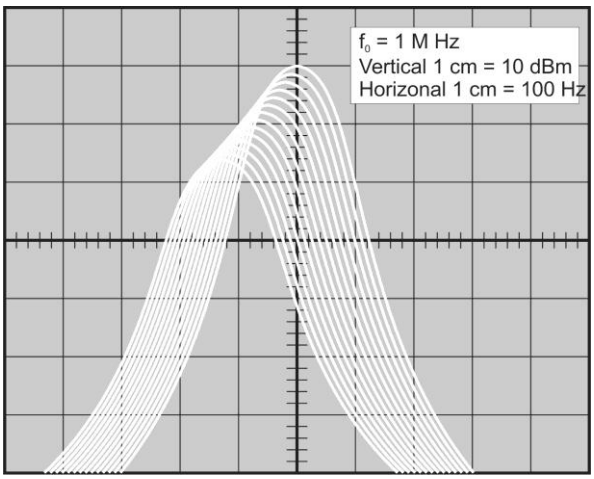

Fig.1: Spectrum-analyzer-display showing the shift of frequency during the process of reducing the amplitude of stable 1 MHz source. The observed shift was proportional to the '*rate*' of reduction of the amplitude.

3. Prediction of Red-Shift Based On the 'Particle' Nature of 'Light':

We know that a photon is a 'particle' localized in a very small region of space. So it can be mathematically represented as an impulse-function, shown in fig.2 below:

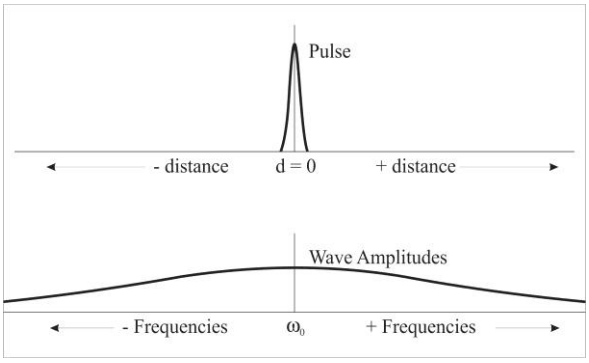

Fig.2: A single photon can be mathematically represented as an impulse-function (top), which can be Fourier-transformed as a wide band of frequencies (bottom). So a 'particle' called 'photon' contains a wide band of frequencies. One particle = a wide-band-of-waves; this is the correct 'wave-particle-relation'.

And a train of photons in space-domain or time-domain can be represented in the frequency-

domain as discrete spectral-lines within an envelope, as shown in fig.3, below:

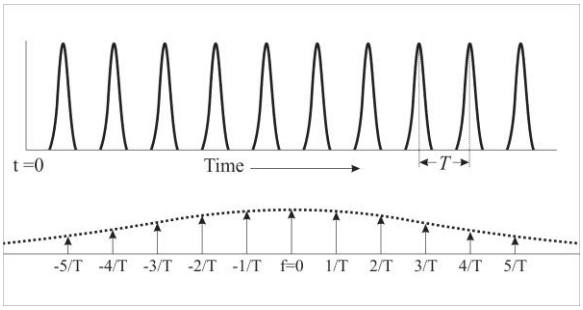

Fig.3: A train of 'particles' called 'photons' in time-domain (top) can be Fourier-transformed as a set of discrete frequencies (bottom).

Now, as we move away from the source of light, the number of photons received in unit time and area goes on reducing, and its corresponding spectrum is expected to go on shifting towards the zero-frequency; as shown in fig.4 below:

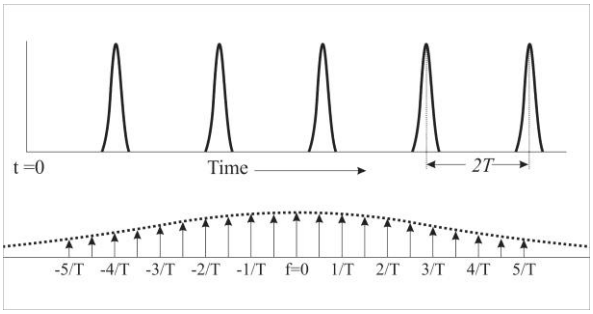

Fig.4: As the distance or time-interval *T* between the photons gets doubled, compared to the previous figure (top), the corresponding 'spectrum' is mathematically expected to shrink, towards zero-frequency (bottom).

The figure-3 and 4 suggest that the expected 'shift-of-spectrum' with distance would be a new 'propagation-property' of spherically-expanding-light.

4. Spherically-Expanding-Wave of Light Viewed as an Expanding-Cavity-of-wave-guide:

Lord Rayleigh, in his 1897 paper [1], published in The Philosophical Magazine, titled: "On the passage of electric waves through tubes…" had, for the first time, derived the expression for group-velocity-of-EM-wave:

$$v_G = c\,[\,1 - (\,\lambda / 2\,a\,)^2\,]^{1/2}\,,$$

Where λ is wavelength of the EM-wave, and *a* is radius of the tube…….(1)

Albert Einstein, in his 1905 paper [2], published in Annalen der Physik, titled: "On the electrodynamics of moving bodies", he assumed v_G as relative-velocity of material objects. [It may be interesting to recall that Michelson-Morley-Experiment was performed in 1887, Lord Rayleigh's paper in 1897, and Einstein's paper in 1905]

Now, if we assume that velocity of a 'photon' is close-to-but-slightly-smaller-than-*c*, say, 10^{-40} *c*, and visualize *a* as an 'expanding-radius-of-the-spherically-expanding-wave-front', then we can expect the wavelength λ to increase with the increase of *a*. After-all a 'photon' is a 'particle' carrying some energy, so its velocity can be slightly smaller than the velocity of electromagnetic-waves, so its wavelength:

$$\lambda = D\,[\,1 - (\,v_{\text{photon}}/c_{\text{velocity of EM waves}})^2\,]^{1/2} \ldots\ldots(2)$$

Where, $[\,1 - (\,v_{\text{photon}} / c_{\text{velocity of EM waves}})^2\,]^{1/2}$ can be as small as 10^{-40}

5. Spherically-Expanding-Wave of Light Viewed as Slightly-Mismatched-Transmission-Line:

Thirdly, it may not be a hundred-percent correct assumption, that there is no reflected-power during the transmission of light through intergalactic-space, because: the characteristic-impedance of free space is 377 ohms, but wave-impedance of a waveguide-cavity depends on cut-off frequency, which depends on radius of the cavity. Therefore, the wave-impedance of spherically-expanding-cavity keeps on changing with radial-distance from the source, and as we know, wherever there is a difference between in-put and out-put impedances, some of the power gets reflected. So, there is a possibility of reduction of energy of the galactic

photons, due to some power getting reflected back to the source.

6. Conclusion:

(i) We first considered light as a 'wave'; and found that depending upon the 'rate' of reduction of amplitude of the wave, its frequency also gets red-shifted; as long as the process of reduction is in progress. The intensity of star-light that we receive on earth is not just 'reduced'; rather it is 'reducing', as per the Big-Bang-Model; and the rate of its reduction varies with our distance from the source. (ii) If we consider light as a stream of 'particles', then also the reduction of flux means increased spatio-temporal interval; leading to red-shift of the spectrum with distance. (iii) If we consider the spherically-expanding-wave-front of light as an expanding-wave-guide-cavity, in which photons travel at slightly smaller velocity than EM-waves; then also we expect the increase of wavelength with expansion of cavity. (iv)The wave-impedance of a cavity depends on its radius; and in the case of spherically-expanding-wave-front of light, the wave-impedance keeps on changing with distance; so there is an in-put out-put mismatch, which is likely to cause some reflected power back towards the source. Various new propagation-properties of light, considered here, are likely to lead to a possibility that: what expands is just the wave-front of the spherically-expanding-wave; and not necessarily the 'space', or the 'universe'! Rather, this new propagation-property of light is likely to be found useful for understanding 'gravity' in terms of waves.

References:

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