# An Explanation for the Observations of ‘wave’/ ‘particle’ nature of ‘Light’ and the ‘Cosmological red-shift’

**Hasmukh K. Tank**

Indian Space Research Organization

22/693 Krishna Dham-2, Vejalpur, Ahmedabad-380015, India

e-mail: tank.hasmukh@rediffmail.com, hasmukh.tank1@gmail.com

**Abstract:** It is well known, that in some experiments, light exhibits ‘wave’ property; like interference and diffraction; whereas in other experiments, like photoelectric effect, it shows ‘particle’ nature. So, the physicists currently think in terms of wave-particle-duality of light. Here, in this letter, it is intended to explain this ‘wave-particle-duality’; and then this insight is applied to understand the observations of ‘cosmological red shift’.

**Key Words:** Wave-particle-duality, Cosmological red shift, Fourier transform

**Introduction:**

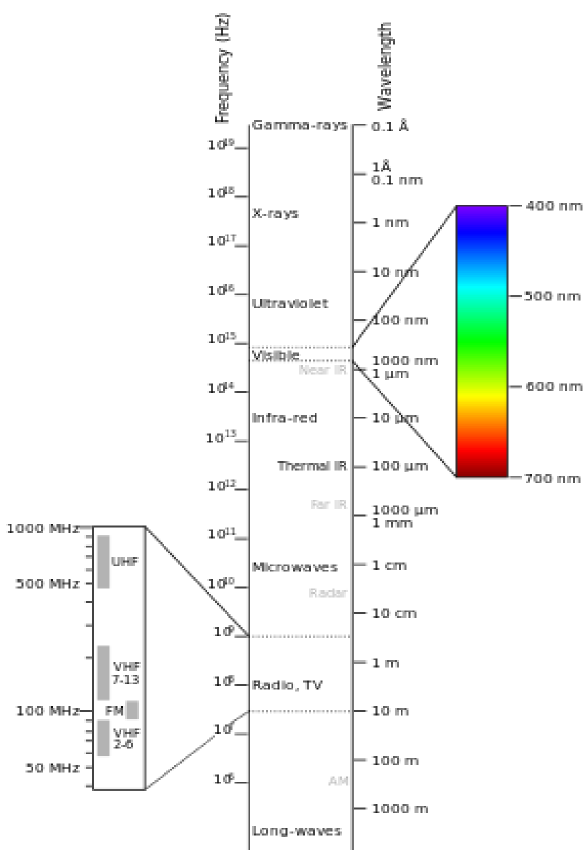


Fig.1: The electromagnetic spectrum

We know, that ‘light’ is a small band of the electromagnetic spectrum, as can be seen from the fig. 1: But in the experiments, always a ‘particle’, known as ‘photon’, is detected; which is localized in a very small region of space. So it can be mathematically represented as an impulse-function, shown in fig.2 below: [1-5]

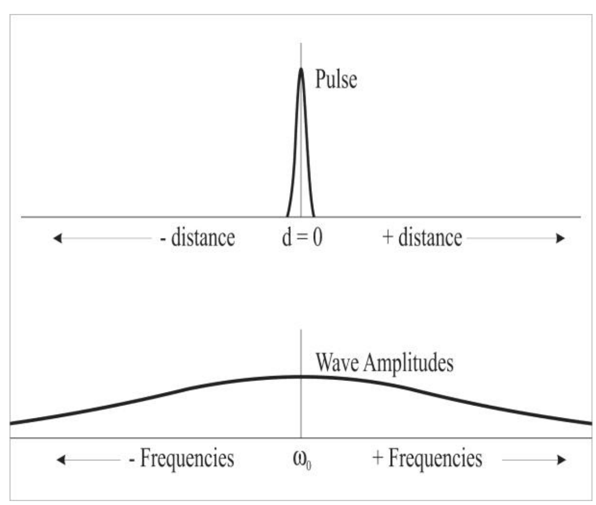


Fig.2: A single photon can be mathematically represented as an impulse-function (top), which can be Fourier-transformed as a wide band of frequencies (bottom). So a ‘particle’ called ‘photon’ contains a wide band of frequencies.

If we take a small, narrow, band of the total band of the fig.2 (bottom), then we get a 'wave packet' as shown in fig.3.

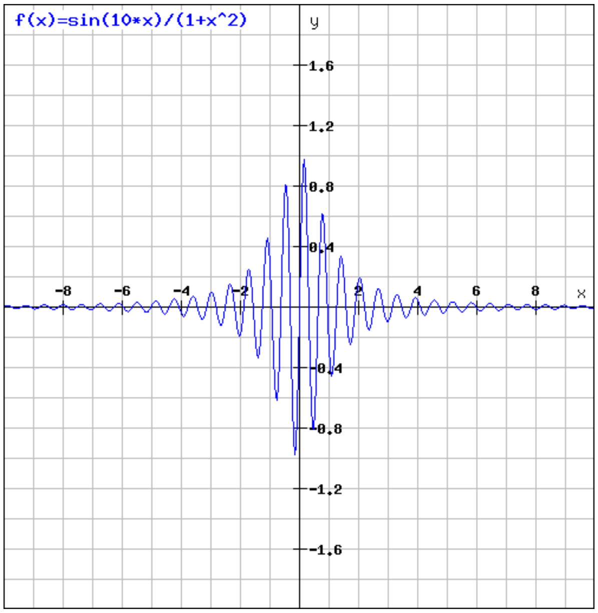


Fig.3: A small, narrow band, taken from the total wide band of the electromagnetic spectrum, looks like a wave-packet in the time domain.

**Explanation for the wave-particle-duality:**

Physical experiments performed on light, for example, the experiment of photoelectric effect, must have contained quite a 'band' of frequencies, not just a single frequency; so in the time-domain, and in the space-domain, it must have been like the 'wave packet' shown in fig.3; and not a continuous wave. Therefore, it was a localized pulse, in the space domain. The light emitting atoms emit such pulses. And high intensity of light means more number of atoms emitting such pulses. At the high frequencies, like those of light, it is not possible to get very narrow-band filters, so there is always some 'line-width' of every source of light; and so we observe localized pulses in the time and space domain. But at radio frequencies narrow-band filters are possible, so we can see low-frequency-electromagnetic-waves as 'waves'; and not as 'particles'. If electromagnetic radiation were always in the form of 'particles', then even at low frequencies we should see 'particles' and not the 'waves' like radio waves, seen on oscilloscopes.

**Explanation for the 'Cosmological Red Shift':**

From the fig.2 (top), we find that a single pulse has a continuous spectrum as shown in fig.2 (bottom). And a train of photons in space-domain or time-domain, as shown in fig.4 (top), when Fourier transformed, into frequency-domain, yields discrete spectral-lines within the same envelope, as shown in fig.4 (bottom):

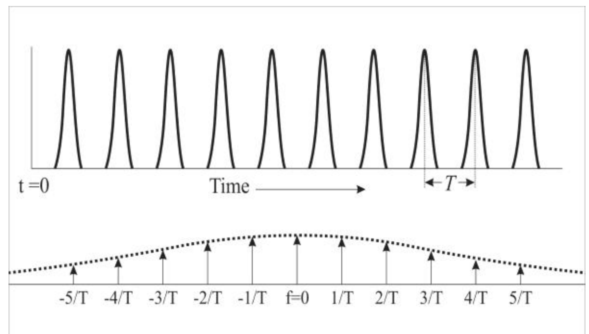


Fig.4: A train of 'particles' called 'photons' in time-domain (top), Fourier-transformed, yields a set of discrete frequencies (bottom).

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.5:

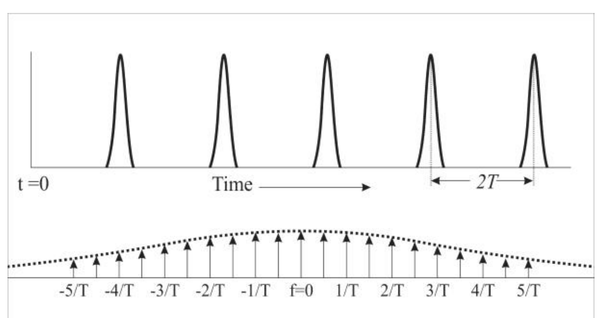


Fig.5: As the distance or time-interval $T$ between the photons gets doubled, compared to the previous figure 4 (top), the corresponding 'spectrum' is

mathematically expected to shrink, towards zero-frequency, as shown in fig.5 (bottom).

The figure-4 and 5 explain, why we observe the ‘cosmological red shift’. As the interval between the photons increase, their spectrum shifts toward zero frequency. This ‘shift-of-spectrum’ with distance would be a newly-proposed ‘propagation-property’ of spherically-expanding-light.

The intensity of light reduce with distance as:

Flux $l$ = Luminosity L / 4 pi $D^2$ $(1+ z)^2$,……..(1)

i.e. Flux $l\,\lambda_0^2$ = Luminosity L / 4 pi $D^2\,\lambda^2$ …..(2)

Where: $D$ is distance of a galaxy from us; and $z$ is ‘cosmological red shift’, and $\lambda_0$ and $\lambda$ wavelengths of light at the source and receiver respectively. From the expression-2 we get the supportive evidence for our discussion based on fig. 5, that with the reduction of intensity of light, the rate of photons received by us go on reducing; and so its frequency-domain representation, goes on shifting towards zero frequency; which we have been thinking as the ‘cosmological red shift’!

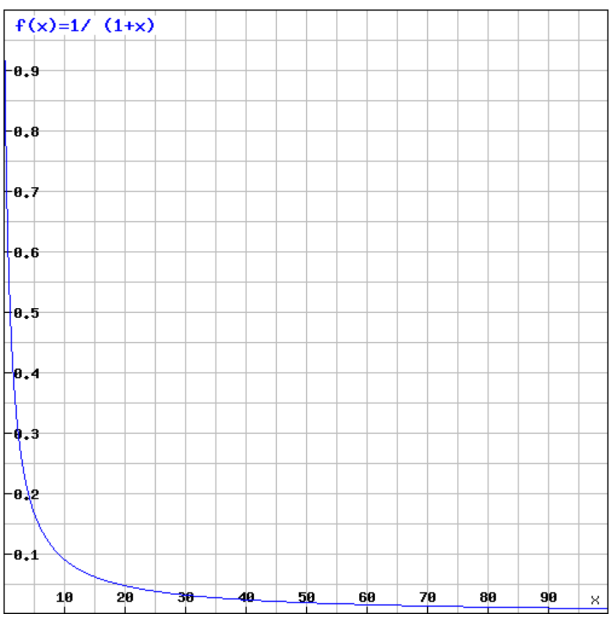


Fig.6: Intensity of light reducing with distance in wavelengths.

From the fig.6, we find that: most of the intensity gets reduced within a few wavelengths; and at very far astronomical distances the rate of reduction of intensity is very less; so we observe very less red shifts at astronomical distances.

**References:**

[1] Tank, H. K. “Some Expressions for Gravity without the Big *G* and their Possible Wave-Theoretical-Explanation”, Progress in Physics, Vol.1, (2013) pp 3-6

[2] Tank, H. K. “Some Proposals for More Experiments on Light to Understand the Observations of ‘Cosmological Red-Shift’”, viXra:1402.0086 (2014)

[3] Tank, H. K.“Some Insight into the outcome of Double-Slit-Experiments”, viXra:1401.0163 (2014)

[4] Tank, H. K. “Can the Big Bang Be So Precise?”, viXra: 1312.0175 (2014)

[5] Tank, H. K. “On the Emergence of the Physical-World from the Ultimate Reality”, viXra:1312.0084 (2014)