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:

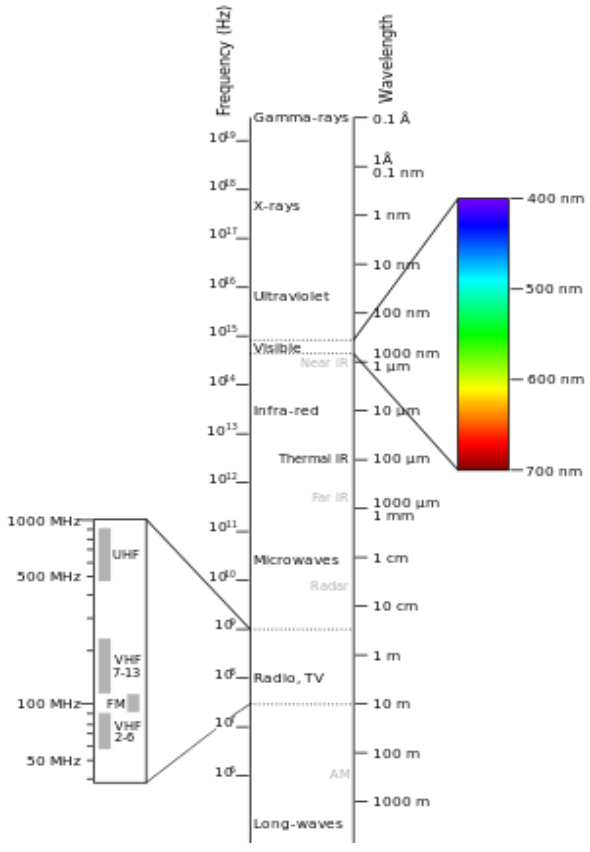

Fig.1: The electromagnetic spectrum

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:

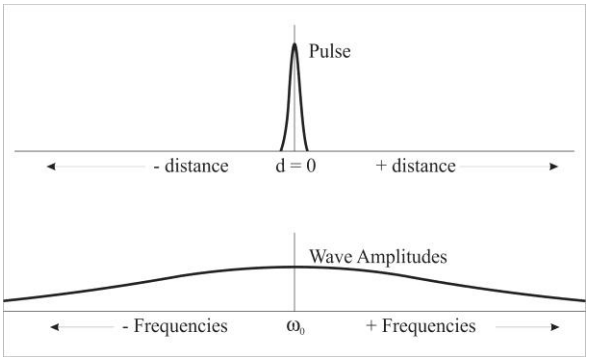

Fig.2: A single photon can be mathematically represented as an impulse-function (top), which can be Fourier-transformed as a wide band of frequencies (bottom). So a 'particle' called 'photon' contains a wide band of frequencies.

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.

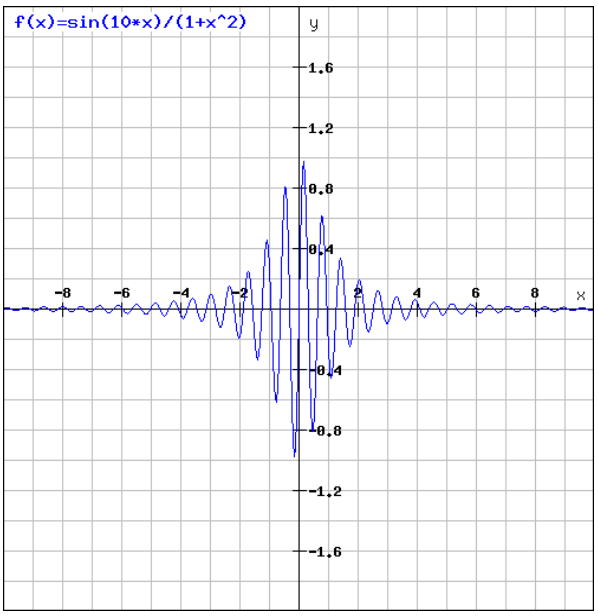

Fig.3: A small, narrow band, taken from the total wide band of the electromagnetic spectrum, looks like a wave-packet in the time domain.

Explanation for the wave-particle-duality:

Any physical experiment 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 a 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. But at radio frequencies narrow-band filters are possible, so we can see low-frequency-electromagnetic-waves as 'waves'; and not as 'particles'.

Explanation for the 'Cosmological Red Shift':

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.4:

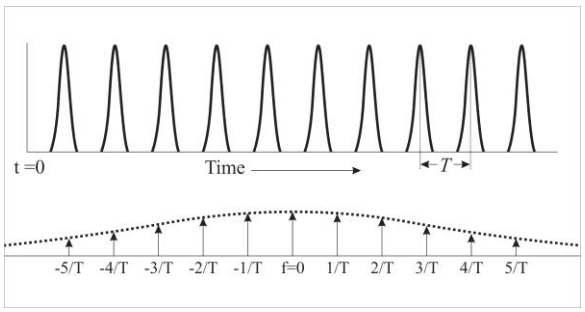

Fig.4: A train of 'particles' called 'photons' in time-domain (top) can be Fourier-transformed as a set of discrete frequencies (bottom).

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.5:

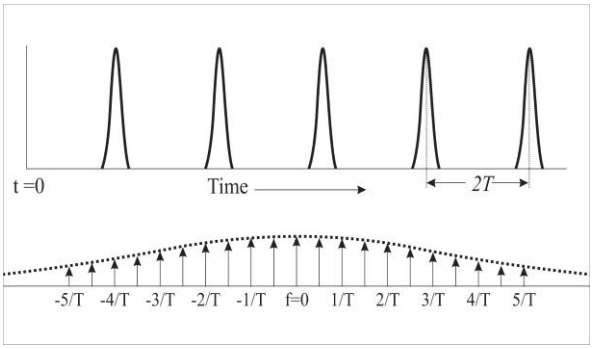

Fig.5: As the distance or time-interval *T* between the photons gets doubled, compared to the previous figure (top), the corresponding 'spectrum' is mathematically expected to shrink, towards zero-frequency (bottom).

The figure-4 and 5 explain, why we observe the 'cosmological red shift'. 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)

Where: D is distance of a galaxy from us; and z is 'cosmological red shift'. From the expression-1 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’!