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Opinion

Calculations to Establish How Far Visible Light Travels before Dropping Out of Sight

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Abstract

The purpose of this study is to determine the maximum distance light can travel before it attenuates below the visible frequency range, i.e., drops out of sight. As light travels extreme distances through space, its frequency slowly diminishes (attenuates). We observe this phenomenon as a redshift, the tendency of visible light to drop toward the red end of the spectrum. When redshift is properly understood, its measurements enable us to calculate at what distance light continues to attenuate beneath the visible spectrum. Beyond this limiting distance, there are countless billions of galaxies that are invisible to us.

Keywords

Light; Attenuation; Redshift; Cosmology; Astrophysics; Universe; Galaxies

The Redshift Blunder

In 1915, astronomer Vesto Slipher observed that light from some spiral nebulae is redshifted and falsely presumed he was witnessing a light source rapidly moving away from the observer and somehow stretching the wavelength of light it emits [1]. This is an impossibility. Slipher did not understand how light attenuates and mistakenly believed he was witnessing a Doppler effect [2].

Redshift and Doppler are two fundamentally different phenomena. In redshift there is an actual increase in wavelength. In Doppler, there is only the illusion of a change in wavelength. Redshift is attenuation whereas Doppler is distortion. To presume they are the same Doppler-redshift is rather like referring to a line in geometry as being a straight-curve [3].

Light waves are transverse (i.e., oscillate perpendicular to their path) and do not require any medium through which to travel. Sound waves are longitudinal (i.e., vibrate parallel to their path) and can only propagate by compression and rarefaction of the medium through which they travel (e.g., air, water, solids). Light travels through outer space. Sound cannot.

If the source of a sound is moving towards you, identical length waves hit your ear more frequently, distorting the perceived sound to a higher frequency. As a sound source moves away from you, identical length waves hit your ear less frequently, distorting the perceived sound to a lower frequency. This is the Doppler effect [3].

Redshift is Attenuation

Over extreme distances, light attenuates according to the following equation $c = \lambda f$

where c = speed of light; λ = wavelength of light; and f = frequency of light wave.

What $c = \lambda f$ tells us is that as the frequency of light drops over extreme distances, its wavelength correspondingly increases. For over a century, astrophysicists have paid more attention to wavelength than to frequency of redshifted light.

The farther light travels, the greater the degree to which its frequency slowly diminishes. We observe this phenomenon as a *redshift*, i.e., the tendency of visible light to drop toward the red end of the spectrum. The farther away a galaxy is, the more its light shifts toward the red end of the spectrum.

If a distant source emits light in the middle of the spectrum, it can be in the red end of the spectrum by the time we receive it. If, however, that source emits light in the blue end of the spectrum, it will have redshifted but could still be in the blue range by the time we receive it. There is no such thing as a "blueshift" whereby wavelengths shorten and frequency increases. All light is redshifted. Light cannot behave in any other way.

Because the surface temperature of the Sun is $5,500^0$ C, it emits light in the yellow range of the spectrum. A star with a surface temperature of $12,000^0$ C emits light in the blue end of the spectrum, and one with a surface temperature of $3,000^0$ C emits light in the red end of the spectrum.

If Star ***X*** at a temperature of 7,000⁰C and Star ***Y*** at 12,000⁰C are the same distance from Earth, we could simultaneously be receiving light from ***X*** in the red end of the spectrum and light from ***Y*** in the blue end of the spectrum. The temptation is to conclude that light from ***X*** is redshifted and light from ***Y*** is blueshifted, but that would be a mistake. The light from both ***X*** and ***Y*** is being attenuated (redshifted) at the same rate. It is only because light from ***Y*** started out at a much higher frequency that it has not yet dropped into the red range of the spectrum.

Redshift is a function of two variables only: (1) frequency at source, and (2) distance travelled. If we know the frequency at source, the frequency at our point of observation can tell us how far that light has travelled. This is all that redshift can tell us. Nothing more.

An Infinite Universe

The alleged big bang never happened. That the universe could have begun from any kind of singularity is both logically impossible and scientifically indefensible. There is no point in time at which time began. Time is in the universe; the universe is not in time. The universe is a limitless, endless infinite expanse that is without beginning or ending [4].

Space is in the universe; the universe is not in space. Space has no shape and no boundaries. Space is an endless expanse within the infinite universe [4].

Galazy GN-z11

Galazy GN-z11 enables us to estimate rate of attenuation over its distance of 13.39 billion light-years. Light from GN-z11 is dull red, and its frequency is documented by NASA as being in the low red range of the spectrum [5, 6].

The frequency of visible light ranges from a high of 800 THz to a low of 400 THz. What we know is the frequency of light from GN-z11 at our point of observation (low red). What we do not know is the frequency of light from GN-z11 at its source.

Scenario A

Suppose that GN-z11's frequency at source (f_s) is 590 THz (mid spectrum) and its frequency received (f_{obs}) is 410 THz (low red). This would mean that over 13 billion light-years (Gly), frequency from GN-z11 has dropped by 180 THz. This is equivalent to frequency dropping every billion light-years to 0.9811 of the frequency of the previous billion light-years. We can thus express redshift attenuation (**R_A**) by the following equation in which distance (***D***) is in incremental units of one billion light-years (Gly).

$$R_A = f_{obs} = f_s (0.9811)^D$$

When its frequency drops below 400 THz, light is no longer visible. It continues at the speed of light but as electromagnetic energy that cannot be seen. This would happen for GN-z11 at 15 Gly

Scenario B

Suppose that GN-z11's frequency at source (f_s) is 790 THz (high blue) and its frequency received (f_{obs}) is 410 THz (low red). This would mean that over 13 billion light-years (Gly), frequency from GN-z11 has dropped by 380 THz. This is equivalent to frequency dropping every billion light-years to .9508 of the frequency of the previous billion light-years. We can thus express redshift attenuation (**R_B**) by the following equation in which distance (***D***) is in incremental units of one billion light-years (Gly).

$$R_B = f_{obs} = f_s (0.9508)^D$$

When its frequency drops below 400 THz, light is no longer visible. It continues at the speed of light but as electromagnetic energy that cannot be seen. This would happen for GN-z11 at 14 Gly.

Unseen Galaxies

From the above calculations we can draw two conclusions: (1) The extreme distances that light travels is more significant to its rate of attenuation than is its frequency at source; and (2) The maximum distance that visible light can travel before dropping out of sight is likely to be 15 billion light-years (Gly).

The Hubble Space Telescope creates for us a spherical horizon with a radius of 13.4 billion light-years. We have no way of knowing what lies beyond this horizon. The above analysis suggests that between 13.4 and 15 Gly there may be one or more galaxies visible to us in the low red frequency range (410 THz.). However, beyond 15 Gly no galaxies will be visible because the frequency of the light they emit has dropped below the visible spectrum creating the illusion that we would be looking out at empty space.

It is a convenience of nature that there should be a maximum distance that visible light can travel. Were this not so, the night sky would be ablaze with a patchwork blanket of light rendering us incapable of distinguishing one celestial object from another. We would never be able to understand the cosmos or our place in it [3, 7].

Conclusion

Over extreme distances through space, the energy of light gradually diminishes (attenuates). We observe this phenomenon as a redshift, the tendency for the frequency of light to drop toward the red end of the spectrum. Redshift measurements indicate that the maximum distance light can travel may be 15 billion light-years, at which distance it will have attenuated into a frequency range that is below the visible spectrum. Beyond this 15 Gly limit there are countless billions of galaxies that are invisible to us.

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