**QUESTIONING THE COSMOLOGICAL DOPPLER RED-SHIFT**

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Earth, effectively a stationary observer, receives red-shifted light from a star speeding away at 0.2c. The amount of red-shift, i.e., frequency reduction/wavelength increase, based on traditional Doppler Effect formulae, is c/(c + 0.2c) = 0.833 (frequency reduction) or (c + 0.2c)/c = 1.2 (wavelength increase). If viewed as a cosmological red-shift, the corresponding “z” value is (1.2 – 1)/1 = 0.2 [or, (1 – 0.833)/0.833 = 0.2]. All these calculations assume light travels at the fixed speed c and any red-shift is due to a “change” in the waveform (i.e., “shape” of the wave, analogous to “stretching” a spring), not a change in light speed. Other types of waves (sound, water, etc.) propagate as “pulses” through a medium, where the matter (e.g., air or water molecules) interact with each other to produce and propagate the “pulse.” Except for some longitudinal (sound) or transverse (water) movement among the matter, the matter itself essentially “remains in place.” These waves also have fixed propagation speeds, given “fixed” physical properties such as temperature, pressure, density, viscosity, etc., and form the basis for the Doppler Effect formulae.

Light has been assumed to behave similarly, i.e., traveling at a “fixed” speed, again depending upon the medium and its properties, although for the case of light in a “vacuum,” no medium is deemed necessary. In fact, the only effect of a “medium” (e.g., interstellar or intergalactic “dust,” gas or plasma) is to retard the light speed relative to its maximum possible value of c in a vacuum which, by definition, is void and thereby cannot constitute a “medium.” Unless one returns to the 19th century concept of the “aether” (and many who question the validity of Einstein’s relativity have done so), what is the basis for assuming that light, if a wave, behaves in the same way as waves whose transmission is dependent upon the interaction of matter in a medium that can transmit “pulses?” One could argue that such a wave (e.g., sound or water) is nothing more than movement of the medium itself, albeit longitudinally (sound) or transversely (water). Without the medium, there can be no wave. Therefore, unless there is an “aether,” how can a light “wave” be analogous to any other type of wave? And (at the risk of sounding somewhat “McLuhanish”), would it not be the fact that “the medium itself is the wave” that results in constant wave speeds for sound or water, given “fixed” physical properties? Therefore, unless light is the movement of a medium (“aether?”), why should it have a fixed speed?

Furthermore, given the previous, why should the traditional Doppler Effect apply to light, especially given that it is considered “more” than just a wave, i.e., the quantum “wave-particle” duality? And, if there is such a medium as an “aether,” why is it totally undetectable, other than theoretically its effect on light (or its movement being light itself)? It would appear to have no physical properties, consist of no form of matter, etc. And, if there is truly no “aether,” and light has no transmitting medium, why assume its “wave” behavior is analogous to waves propagating through a medium (e.g., fixed transmission speed, subject to traditional Doppler Effect)?

An Alternative

Consider another possibility, assuming that light retains some aspect(s) of “traditional” wave-like behavior. Rather than the effect of the star receding at 0.2c being on wavelength and frequency, what if it acts directly to reduce the light speed to 0.8c (Galilean transform), contrary to relativity, constant speed of light, etc.? Assume the waveform (“shape”) remains unaffected, i.e., the frequency and wavelength are the same (no “stretching”), but only the transmission speed changes (is reduced). Whereas a stationary star would emit light at speed c, such that over an increment of time “t,” “n” wavelengths (cycles) of length “w” (m/cyc) would be received at Earth (implying a frequency “f” = n/t), the receding star would emit light at speed 0.8c, reducing the number of wavelengths received over t to 0.8n (with reduced frequency = 0.8n/t). Note that, calculationally, this is equivalent to the “traditional” Doppler effect on frequency, but now with the source (star) stationary and the observer (Earth) receding at 0.2c. Traditionally, the Doppler Effect in this case is (c - 0.2c)/c = 0.8 (frequency reduction), the same value, although quite conceptually different (see Figure 1).

Traditionally, the “length” of the “transmission” is unaffected by the Doppler shift, in that it remains the same whether the star is stationary or receding: stationary “length” = w (m/cyc) \* f (cyc/s) \* t (s) = wft (m); receding “length” = 1.2w (m/cyc) \* 0.833f (cyc/s)\* t (s) = wft (m); both of these = ct. If the light speed is affected rather than the waveform, the receding “length” is shortened as follows: w (m/cyc) \* 0.8f (cyc/s)\* t (s) = 0.8wft (m), i.e., 0.8ct. The corresponding cosmological Doppler Effect “z” value is (1 – 0.8)/0.8 = 0.25, slightly higher (“redder”) than that from the “traditional” approach. Unfortunately, since it is “z” that is used to calculate the star’s recession speed, there would need to be another independent way of calculating that speed to determine which red-shift estimate (0.833f or 0.8f) is correct (if either).

For the case where the star is stationary, there is no Doppler red-shift and 2 full wavelengths (cycles) are shown as traversing the “length” over time t, at frequency 2/t (cyc/s). With the star receding at 0.2c, the “traditional” Doppler red-shift, with light still traveling at c, “elongates” the wave such that only 2/1.2 = 1.67 wavelengths traverse the “length” over time t, at frequency (2 \* 0.833)/t = 1.67 (cyc/s). The corresponding cosmological red-shift is calculated as z = 0.2, from which one would infer the star’s recession speed to be 0.2c. Lastly, with the star again receding at 0.2c, but now assuming the emitted light experiences this as a reduction in speed, rather than a change in waveform, a shorter “length” is traversed over time t, spanned by 2 \* 0.8 = 1.6 wavelengths, at frequency = (2 \* 0.8)/t = 1.6/t (cyc/s). If this were assumed to correspond to the “traditional” Doppler red-shift, the inferred recession speed of the star would be based on z = (2 – 1.6)/1.6 = 0.25, i.e., 0.25c. However, if the Doppler effect is “Galilean,” i.e., the speed of light transmission, not the waveform, is affected by the speed of the source, then the “true” speed of the star is 0.2c (recession).

Analogy with Refraction?

Consider the traditional view for light refraction when entering a denser (or less dense) medium, as shown in Figure 2.[[1]](#footnote-1) The speed slows (or increases), with the full effect of the speed change being carried by a corresponding change solely in the wavelength, i.e., the frequency remains the same. Therefore, there is no change in “color” (using this term loosely to apply to non-visible light as well) since “color” is determined solely by frequency.[[2]](#footnote-2) Consider a similar situation where you are sitting by a swimming pool at midnight gazing vertically upward at the full Moon. Assume the Moon is made entirely of green cheese. Gazing upward through the atmosphere (and “void” of space between the Earth and Moon) for ten seconds, the moon stays green. Now, take a deep breath and dive under the water to the bottom. Again look vertically upward at the full moon for ten seconds. While the image may be blurred from your splash, the Moon remains green, i.e., no “color” change. Although the speed of light decreased when entering the water (this time perpendicularly so there is no refraction), only its wavelength, not its frequency, dropped. Therefore, there was no “color” change. In this case, transmission of light through different media, the speed change is carried by the wavelength, not the frequency.

The two cases are different, however. The Moon and Earth are essentially stationary with respect to one another (at least for the ten-second interval) and the light traverses two different media. The speed changes (considering the void-atmosphere as one medium and the water as the other), but this change is carried only by a change in wavelength, not frequency. There is no “red-shift” (the Moon stays as green as ever). Now, with the star receding relative to Earth but the light not changing its medium (slight difference between Earth’s atmosphere and “void” of space notwithstanding), a “Galilean” Doppler shift due to the decreased light speed is carried solely by a decrease in frequency. There is no wave “stretching," i.e., the wavelength does not change. However, the “length” of the wave reaching the observer over the same time period is reduced, therefore corresponding to a frequency reduction and, therefore, a red-shift.

Absent the identification of a propagating medium for light, what is the basis for assuming the “wave” portion of its behavior is the same as that for waves propagating through tangible media? Why would the wave from a receding source necessarily “stretch” while that from an approaching source “compress?” If we do not assume light speed is constant in a given medium (or, in the case of interstellar or intergalactic space, no medium at all), why would the wave necessarily behave similarly? To factually determine which model (if either) is accurate, one needs to independently measure the star’s speed, independently measure the red-shift, and then see which, if either, formula yields consistent results. Otherwise it is, as with most of the basis for relativity, more theoretical speculation than experimental foundation.

Conclusion

However, after having discussed all this and having proposed an alternate version of the cosmological Doppler red-shift, I must state that I do not believe in an expanding universe or even rapidly receding stars, galaxies, etc. Assuming no form of matter, especially a reasonably macroscopic and tenuous one like a star, let alone an entire galaxy, could possibly travel at speeds approaching that of light and remain “intact,” the only possible way for such an entity to exhibit recession speeds approaching that of light would be for space itself to be expanding. And whether one accepts the traditional or “Galilean” Doppler red-shift as the correct explanation, one is still left to conclude that “something” is “racing away.” Therefore, I believe the “correct” explanation for the “apparent” expansion of the universe is one of the various “tired light” theories (or one yet to be proposed), whereby light’s interaction with interstellar and/or intergalactic media reduces its energy, resulting in a non-Doppler red-shift.

Various theories, such as gravitational “de-energization,” Compton scattering, “dust” absorption-re-emission,” quantum electro-dynamical interactions, are among many that have been proposed. All reduce the light energy, which can be viewed traditionally as a decrease in frequency with (traditionally) or without (“Galileanly”) a corresponding increase in wavelength. Either way, a red-shift (non-Doppler) occurs. My goal in this paper has been not to resolve which of these “tired light” theories is most plausible, but to cast doubt on the traditional explanation of a cosmological Doppler red-shift due to universe expansion. A “Galilean” Doppler red-shift may be an equally plausible explanation for those who adhere to the premise of stars, galaxies, etc., “receding” for whatever reason.

Light from stationary star (grey circles from x = 0 to x = 2, i.e., 2 wavelengths) [Sin(x)@1.0c]

“Galilean-shifted” light from receding star (black triangles from x ≈ 0.4 to x = 2, i.e., 1.6 wavelengths) [Sin(x)@0.8c]

**Figure 1.**

Earth (stationary)

“Traditional” Doppler-shifted light from receding star (grey squares from x = 0 to x =2, i.e., 2/1.2 = 1.67 wavelengths) [Sin(x/1.2)@1.0c]

Star (either stationary or receding to left at 0.2c)



**Figure 2.**

1. [*http://www.bing.com/images/search?q=refraction+of+light&qpvt=refraction+of+light&FORM*](http://www.bing.com/images/search?q=refraction+of+light&qpvt=refraction+of+light&FORM)*=IGRE#view=detail&id=E1665849CC7E68512A240617ACC9D06A1507E84C&selectedIndex=54* [↑](#footnote-ref-1)
2. It is a common misconception that “color” can be equivalently characterized by wavelength or frequency, unless one is speaking solely of travel through the same medium, where the light speed is constant (for stationary source and observer) and, therefore, a change in one reciprocally changes the other. The fact that there is no “color” change during refraction demonstrates that “color” is really a function solely of frequency. [↑](#footnote-ref-2)