Questioning the Cosmological Doppler Red-Shift

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Linked with the concept of a cosmological Doppler red-shift is an expanding universe with 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' (except, perhaps, something as dense as a neutron star), 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.' I endeavor 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.

1. Introduction

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" is what 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 via 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)?

2. 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) x f (cyc/sec) x t (sec) = wft (m); receding length = 1.2w (m/cyc) x 0.833f (cyc/sec) x t (sec) = 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) x 0.8f (cyc/sec) x t (sec) = 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 two full wavelengths (cycles) are shown in Figure 1 as traversing the length over time t, at frequency 2/t (cyc/sec). 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 x 0.833)/t = 1.67 (cyc/sec). 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 x 0.8 = 1.6 wavelengths, at frequency = (2 x 0.8)/t = 1.6/t (cyc/sec). 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).

3. Analogy with Refraction?

Consider the traditional view for light refraction when entering a denser (or less dense) medium, shown in Figure 2 *(http://www.bing.com/images/search?q=refraction+of+light&qpvt=refraction+of+light&FORM=IGRE#view=detail&id=E1665849CC7E68512A240617ACC9D06A1507E84C&selectedIndex=54).* 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. (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.)

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 the 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.

4. 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' (except, perhaps, something as dense as a neutron star), 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 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.

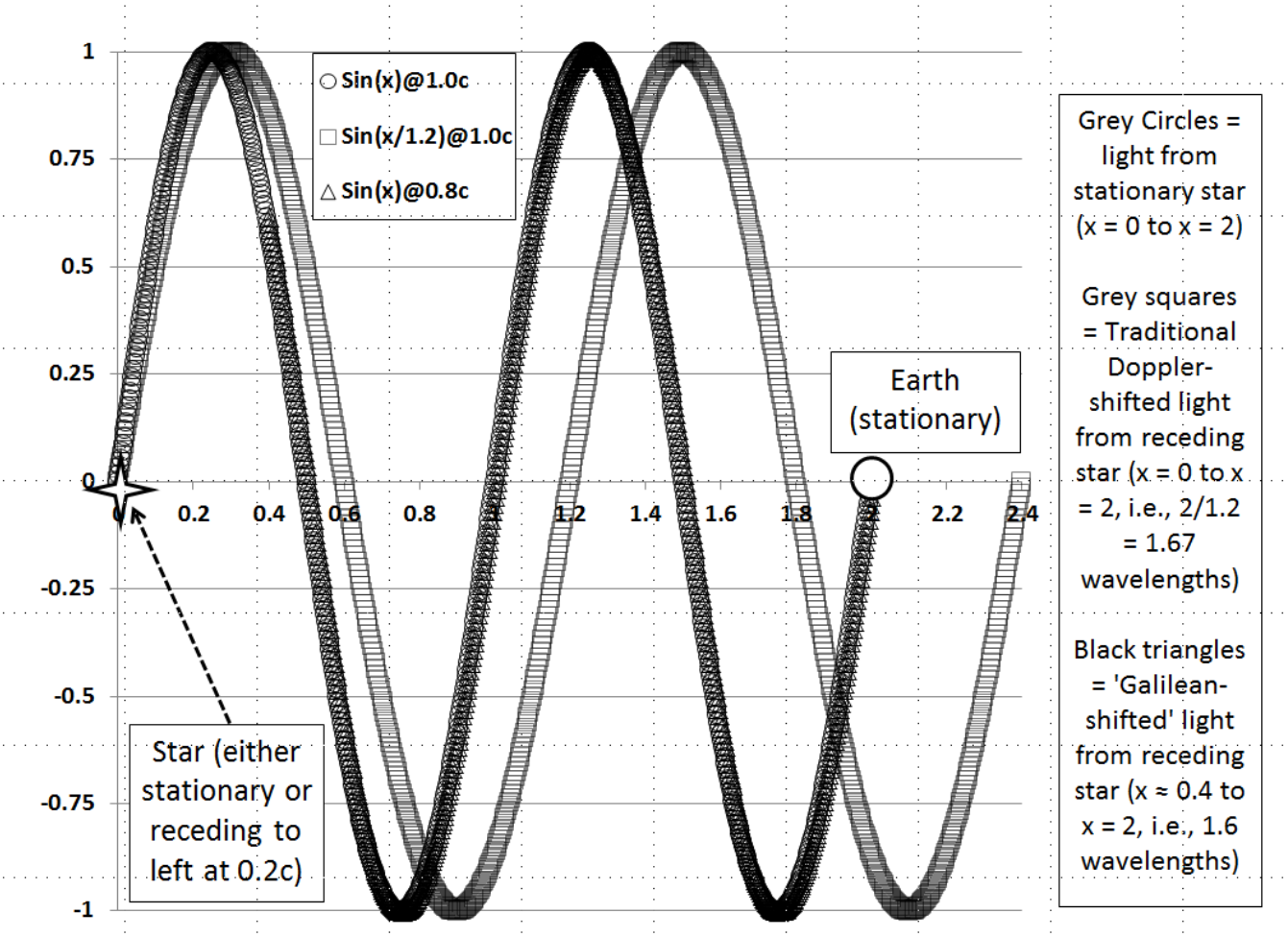

FIGURE 1. 'Galilean' vs. Traditional Doppler Shift for Stationary vs. Receding Star

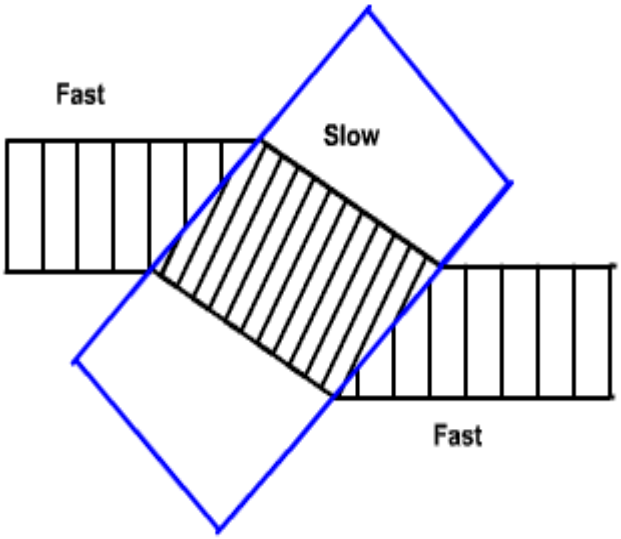

FIGURE 2. Light Refraction upon Passing Through a Denser Medium

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- Linked with the concept of a cosmological Doppler red-shift is an expanding universe with rapidly receding stars, galaxies, etc.
  - Can a reasonably macroscopic and tenuous form of matter like a star, let alone an entire galaxy, possibly travel at speeds approaching that of light and remain 'intact' (except, perhaps, something as dense as a neutron star)?
    - The only possible way to exhibit recession speeds approaching that of light would be for space itself to be expanding.

???ing the Cosmological Doppler Red-shift

- 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.'
- 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.
  - Might this support one of the 'tired light' theories?

Traditional Red-shift

- Assume 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].
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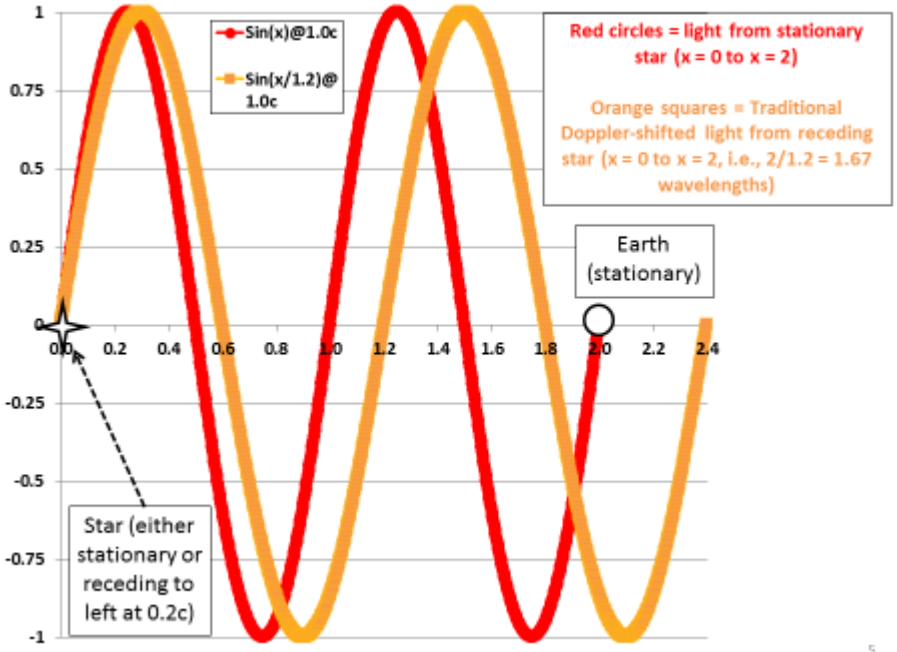

Traditional Red-shift

- 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.

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- Light has been assumed to behave similarly, i.e., traveling at a fixed speed, again depending upon the medium and its properties, although for light in a vacuum, no medium is deemed necessary.
  - Unless one returns to 19th century concepts of 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?

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- Furthermore, why should the traditional Doppler Effect apply to light, given that it is considered more than just a wave, i.e., the quantum wave-particle duality?
- 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.
- If 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

- Assume that light retains some aspect(s) of traditional wave-like behavior.
  - What if the effect of the star receding at 0.2c 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).
      - 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)
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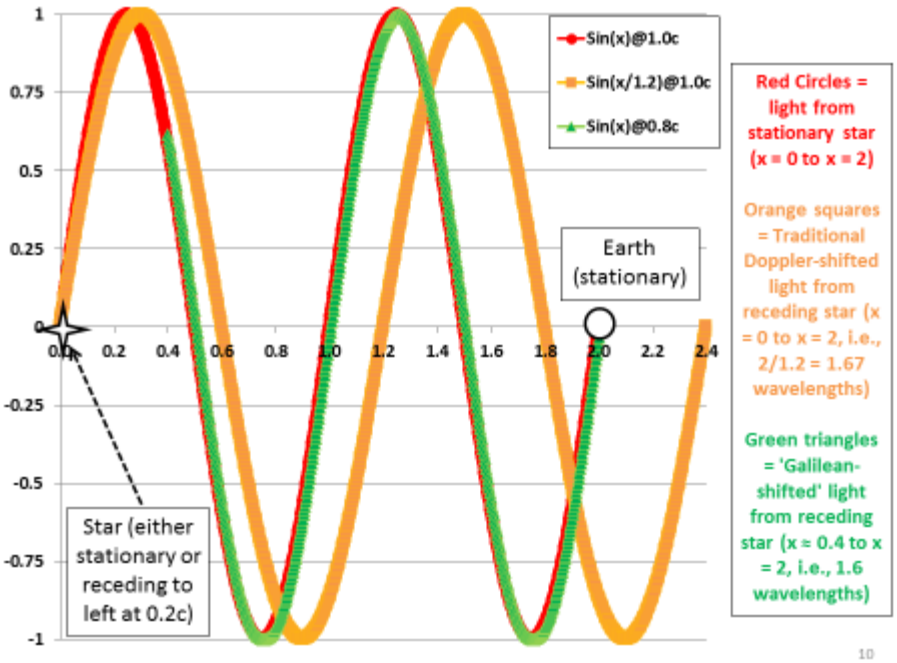

An Alternative

- 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) x f (cyc/sec) x t (sec) = wft (m) = ct (m)
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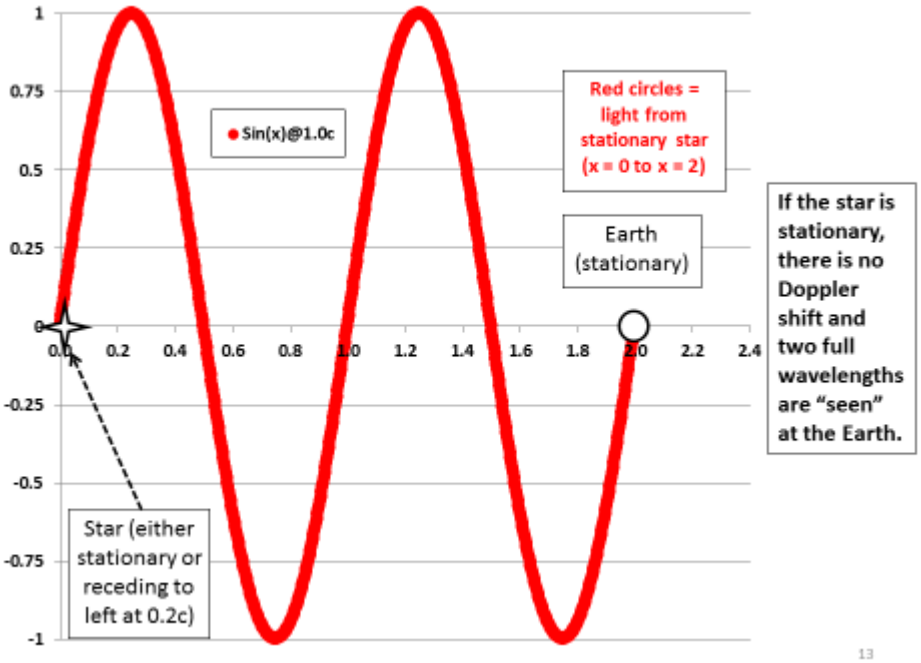
- If the light speed is affected rather than the waveform, the receding length is shortened as follows:
  - w (m/cyc) x 0.8f (cyc/sec) x t (sec) = 0.8wft (m) = 0.8ct (m)
    - The corresponding cosmological Doppler Effect z value is (1 – 0.8)/0.8 = 0.25, slightly higher ('redder') than that from the traditional approach (0.2).

The Dilemma

- Since z 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).
- Let us examine:
  - If star is stationary, there is no Doppler red-shift and two full wavelengths (cycles) are shown in the next slide as traversing the length over time t, at frequency 2/t (cyc/sec).



The Dilemma

- Let us examine (continued):
  - 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 x 0.833)/t = 1.67 (cyc/sec).
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  - Assuming the emitted light experiences the star's recession only as a reduction in speed, a shorter length is traversed over time t, spanned by 2 x 0.8 = 1.6 wavelengths, at frequency = (2 x 0.8)/t = 1.6/t (cyc/sec).
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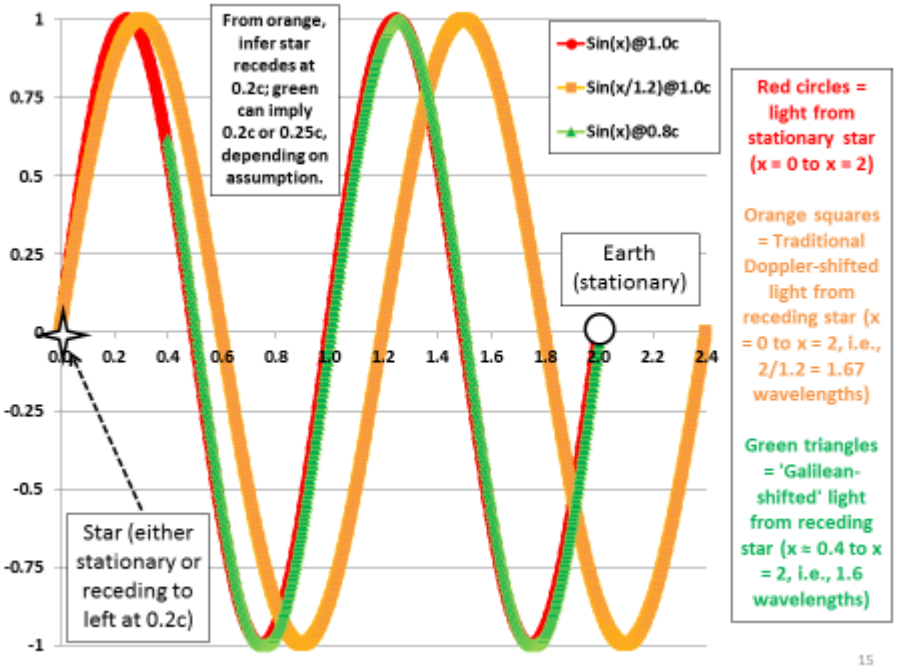

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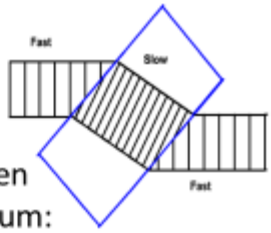
Analogy with Refraction



- Traditional view for light refraction when entering a denser (or less dense) medium:
  - 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., frequency remains the same.
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Conclusion

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Conclusion

- My goal has been not to resolve which tired light theory 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 maintain that stars, galaxies, etc., recede for whatever reason.