Red Light

Introduction

It is, at once, amazing that light can transmit information to us over such large spans of distance and time. This article concerns the interpretation of that information.

What we perceive at our location is probably not the same data that was released from it's source far away and a long time ago. What we perceive is characteristic of the source, the path, time elapsed, and our psychology. Light, and all electromagnetic waves, are a form of energy whether considered as a photon particle or a wave. Communication is the transfer of energy and the recipient must necessarily extract some of that energy to receive the message.

This article will explore the red shift of light from distant galaxies and how to interpret that from a practical engineering and philosophical perspective.

Wave Physics

Waves, whether acoustic or electromagnetic or some other form, are expected to "obey" the wave equation, which is –

$$\lambda = \frac{v}{f}$$

where λ = wavelength in meters
f = frequency in cycles/ second or Hertz
v = speed of the wave in meters/second

This equation is a mathematical invention to describe what we observe and is an idealization. I will assume that this wave equation is valid for the purposes of this article. The important parameters relevant to this article are the frequency and the speed. Let's explore wave properties from the experience of acoustics, arguing by analogy.

Acoustic energy spreads out from it's source in a homogeneous medium (like air) as a spherical wave front. It gets reflected, absorbed, and diffused. It loses energy as it propagates through the medium, which means that the amplitude diminishes. The frequency can also shift downward if there is significant damping. Acoustic waves transmit through matter. The matter, as the medium of transmission, can modify the characteristics of the wave. That means that the speed, the frequency, and consequently, the wavelength can be changed.

Light also spreads out as a spherical wave. The medium here will be considered space along with whatever occupies that space. It gets reflected, absorbed, and diffused or dispersed, depending on how it interacts with space and it's contents. The small dim spot that we see through a lens we interpreted as the light from a distant star and not a speck of dust on our lens. We also analyze that light further with a spectroscope and make a number of assumptions about what we observe. Some of the assumptions are:

- The frequency pattern from the source is similar from all sources.
- Only time of travel affects the distance from the source, that is, no other factors can shift the frequency pattern.
- The speed of electro-magnetic energy (light) is constant during the entire transit time.
- Any interaction with the intervening matter is negligible.
- Light travels in a straight line, or the shortest distance between points.

Acoustic energy, like vibration, also travels along structural paths and is channeled through rigid materials. It is attenuated with distance along that path, but the frequency remains mostly unchanged. That is the physical principle that makes vibration analysis of machinery even possible. With little damping in metal structures, the frequency comes through mostly unchanged. If the frequency shifted during propagation, then there would be no hope of doing vibration analysis of machines and structures. Similarly, if the frequency of light shifted during propagation, then any

analysis of that data would be in doubt. There is some small downward shift in acoustic frequency from the resonant peak if damping is present. The damping also causes the acoustic energy to attenuate in amplitude. It dies away and does not travel very far or for very long. If there was no material damping, then every sound produced from the beginning of time would still be present reverberating through the universe. This would be a noisy place and theoretically possible to extract the conversation from Adam and Eve. That would be an interesting recording which I could become wealthy from and could retire from writing this article. The structural path can also amplify the vibration amplitude if there is a frequency match (resonance) and another source of energy is present, like broadband friction, wind, or fluid flow.

Light can also take structural paths like total internal reflection in fibers, but that is not under consideration here as we are interested in starlight traveling through the void of space. Space is the medium through which starlight propagates. The questions then are –

1. Does space attenuate the starlight with distance?
2. Does it amplify via resonance?
3. Can it change the frequency?
4. Are the frequency, amplitude, and speed time invariant?

These questions will be taken up in the later section on space.

Hubble

Edwin Hubble interpreted the red shift of light from distant stars as a Doppler effect similar to the acoustic shift from a receding train. When the train was moving away from the receiver, the acoustic frequency was dropping because the wavelength was getting longer. Therefore a star exhibiting a longer wavelength i.e. a red shift to a lower frequency, meant that the star must be moving away from us. That assumed that the frequency of the sound wave from the train was constant and that

the observed Doppler shift was solely due to the receding train velocity. Applying this analogy to the light from a star, and assuming that the light frequency from the star was constant, then the red shift from the star meant that the star was moving away from the observer. The general conclusion after observing this red shift from many stars was that the universe was expanding. For this expanding universe conclusion to be true, these assumptions must be accepted.

- All stars emit the same frequency pattern in the optical spectrum of elements.
- That light frequency is time invariant. The frequency remains constant as time passes.
- That light frequency is not modified by encounter with hydrogen atoms in the intervening space. We know that radiation interacts with matter.
- That light waves are 100% efficient and do not lose energy and do not violate the second law of thermodynamics. (A red shift lowering in frequency implies a loss of energy.)
- The speed of light is constant in a vacuum.

These assumptions must be accepted to believe in the Hubble red shift and an expanding universe with all of it's other bizarre conclusions of the "Big Bang", continuous expansion, dark matter & dark energy, etc.

Suppose the speed of light is not constant in space. Then all of this interpretation is void. A slowing down of the speed of light in space means that it is losing energy. If the wavelength at the source is a known value based upon what we know about the chemistry of elements and some energy is lost in transit, then the frequency must shift downward during transit. Distant object would appear to be moving away, and more distant object would appear to be moving away faster.

Light travels slower in denser media (like diamond). When light slows down in diamond to 80,000 m/s, from 300,000 m/s in vacuum, then it must lose energy. Where does the energy come from to speed it up again when re-entering a vacuum? The answer is that it always had the energy available. It was temporarily stored in the matter since radiation interacts with matter. If light travels slower in

diamond and the frequency remains constant, then it's wavelength should decrease i.e. shift towards the red.

The expanding universe based on the Doppler red shift of light arriving at Earth observers is flawed. The interpretation of the red shift as receding velocity is modified by other processes, for example:

- The gravitational red shift of a photon climbing out of a gravity well.
- The slowing down of light velocity when departing a Black Hole.
- The interaction with hydrogen and helium molecules in interstellar space.
- The inevitable loss of energy over time.
- Light interaction at surfaces. Energy exchanges occur where radiation encounters matter.
- Time does not change. Velocity has time as the denominator – v = ds/dt.

Einstein

The theory of relativity is based on the assumption that the speed of light is a constant everywhere for all observers regardless of their state of motion. This is only probable. Einstein called that a postulate in his 1905 paper “On the electrodynamics of moving bodies”. He argued from the position that suppose light speed is constant in a vacuum, then what conclusion can be drawn from this postulate. That means that the conclusions resulting from this postulate are inductive reasoning and may not be certain, universal, and timeless. In addition to this postulate of the constancy of the speed of light, Einstein made four other assumptions in his 1905 paper. They are –

1. Maxwell’s equations are valid.
2. Symmetry
3. The properties of space are homogeneous.
4. Physical laws are time invariant and valid everywhere for all time.

For the record, Einstein did not immediately accept Hubble's conclusion of an expanding universe and had reservations for the rest of his life. The postulate may be valid i.e. "that the speed of light is in a vacuum is constant", but space may not be a vacuum.

Space

The cosmic microwave background radiation has been suggested as strong evidence for the expanding universe theory. What this measurement actually shows is that space between stars is not empty. It contains some energy with a definite frequency that appears to be uniformly distributed. We also know that "empty" space contains some hydrogen atoms floating around. Light photons or waves traverse this space and could couple to the thin matter there. Light, or any electromagnetic radiation is not like a passive rock, but oscillates. A rock may be gradually slowed by the friction with the hydrogen and helium atoms. Similarly, the light wave interacting with the few atoms in the "vacuum" of space can exchange energy with them, since we know that radiation interacts with matter.

Space between stars is a huge volume of unknowns with a few tidbits of known properties and a lot of assumptions. Whatever properties it has, we would be most interested in those that can affect the speed or frequency of light.

The medium of space would need to have infinite "stiffness" to the propagation of a light wave to not attenuate it (reduce it's speed or amplitude). Faraday suggested that as a possibility in a letter to a colleague in 1824. Any material having infinite properties is imaginary. If light wave energy is not attenuated with distance and time, then we are led to the inescapable conclusion that it is 100% efficient and violates the second law of thermodynamics. It never dissipates. It never dies. The light wave energy that was produced in a star continues on forever. Nothing is forever except death.

The medium of space may have some frequency properties that can amplify the light wave. At the very least, the medium must have some kind of property to support the wave motion, like water

molecules transport wave motion on the oceans. Mechanical vibration waves receive some initial energy from the source impact and can receive additional energy along the path. Light waves receive their initial energy at the source also. An open question is “Can they accept additional energy as they propagate through the medium of space through their interaction with the hydrogen atoms?"

If space has any damping properties, then it can shift the light frequency downward. The principle of radiation interacting with matter suggests that some resistance to light wave propagation must exist. During the interaction, there must be some exchange of energy. Damping implies some resistance, or in the case of an energy with a frequency, some impedance. There is a theoretical impedance of free space defined as

$Z_0 = E/H = \mu_0 c$ where μ_0 is the permeability of free space
c is the speed of light
E is the electric field strength
H is the magnetic field strength

Z_0 = 376.73 Ohms. It is a fictitious resistance. This means that space has frequency properties related to radiation. This impedance may be what limits the speed of light. Free space is an abstract concept that does not exist.

Force & Acceleration

The big bang theory bring up the question of what initiated it. That is a question for theologians to respond to as I have no answer. A more practical engineering consideration is the higher velocity of more distant galaxies. Why should they be moving away from us faster? If they are accelerating, then what is the force causing acceleration? And why are we at the center of this expansion? This all seems to be a self centered perspective which is not atypical for an egocentric species. This all hinges on a particular interpretation of a single set of data points, that things are moving away from the observer. If that interpretation is not correct, then our theory of the universe is all messed up.

Change

Light frequency can be expected to change for many reasons e.g. gravity, time, material interactions. Change is a certainty that we observe of nature as a universal principle. Nothing in the physical world is changeless – not objects, not processes, not systems, nor energy. We can imagine changeless properties, mostly as idealizations in mathematics, like the ratio of the circumference of a circle to it's diameter (the number π). These are imaginary concepts not existing in the real world, only in our minds. It is unrealistic to expect the frequency of light to be forever unchanging. If it is to be a constant, let it be a constant in our imaginations.

Us

The receiver of communication must extract some energy from the measurand to be able to even detect it. That means that we could be the cause of the red shift, beyond the possibility that space and time modify the frequency. If time and space have the capacity to modify the frequency of light, then the red shift can be a measure of distance rather then velocity. It is also possible to deceive ourselves with the myth that some spectrographic wavelength lines displaced to the right (lower frequency) are evidence of divine providence where some deity with immense powers created everything in an instant. That can be a comfortable place for some where hope is abundant and knowledge deficient.

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