Dynamic Chiropractic

PATIENT EDUCATION

The Nature of Science Series #43 Physics XI: The Light Fantastic

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Four billion years ago, on a quasar racing away from the spatial site where the earth is tonight, at half the speed of light (93,150 mps), light arose from its surface and started on its four billion year journey toward us. This quasar is (was) ten times as dense as is our sun, which means that the emitted light had to "rise against" that much more gravity pulling it back and shoot off into space from an object traveling in the opposite direction at 93,150 mps, a speed considered "relativistic." Tonight, four billion years later, we pick up this rectilinearly propagated light in a spectroscope and note a large red shift in the spectrum of that ancient light, light that has been traveling toward this spot in space six trillion miles a year for four billion years, or 2421 miles. Where that quasar is now, what speed it is now traveling, and how dense and how much light it is emitting, if any, is a matter of speculation only. The only real information we have on that object is four billion years old, and it will take another four billion years for us to learn what the condition of that quasar was in earth time, 1989.

In 1931, the calculation of the speed of light was 299,774 kilometers per second, with an uncertainty in the measurement of 11 km. In 1950, the speed of light was measured at 299,792.5 km/sec., and 299,789.3 km/sec for the speed of microwave radiation. By 1952, the speed of light was set at 299,792.7 km/sec (rounded off to 299,800 km/sec). The measurements of the 1970s gave values of 299,792,457 and 299,792,459 meters per second. And in the 1980s, the official speed of light in a vacuum is 299,792,458 m/sec. The International Meter is thus officially defined as the fraction 1/299,792,458th of the distance light travels in one second. Other values for the speed of light are: 299,792.5 km/sec, 30 billion cm/sec (rounded), 11,172,000 mpm (miles per minute), 630,320,000 mph, 3 x 1010 cm/sec or 29,980,000,000 centimeters per second. Confusing? Well, for simple, everyday usage, the figure of 186,300 m/sec (rounded off) is acceptable.

The speed of light in water is about 140,000 m/sec, i.e., it is slowed down by about a fourth in this denser medium. The velocity of light through glass is between 120,000 m/sec to 130,000 m/s, or it is slowed down by about a third. Light is slowed down in its transit through diamond even more. And, it has been known for some time that light goes slower through cooler air than through warmer air.

A light year equals about 5,870,000,000,000 miles of space traversed in a year's time, or 6 x 1012 miles. The speed of light squared -- the c2 in Einstein's famous equation of E = mc2 -- is 9 x 1016 miles. One foot of space equals one nanosecond of time light travels.

Light is a double vector phenomenon: it has (1) spatial direction, (2) magnitude (or intensity) (wavelength height), (3) speed in space, and (4) a specific wave frequency. The movements of light are: (1) straight-line trajectory from the light source into space (its rectilinear propagation), (2) electric up and down waves, (3) magnetic sideways, back and forth waves (both electric and magnetic waves travel as part of the propagating light wave at the velocity of c2, (4) internal spin motion, and (5) rectilinear spreading in space with distance (not a true motion but an effect of light radiation moving out from a specific luminous object or point source -- which results in the "thinning" of light with distance or its dimming).

The five properties common to all waves are: (1) speed: all waves have a finite speed, i.e., they require time to travel any given distance in space; the magnitude of this speed depending on the characteristics of the particular wave and the medium through which it travels. Wave speeds are measured in some sort of units, as a distance unit per time unit, like feet, miles, centimeters per second. (2) wavelength: the wavelength of any type of wave is of considerable importance in determining how the wave behaves and what effects it produces. By convention, the wavelength is the distance between successive wave crests. Radio waves are very long from crest to crest, from about 200 to 600 meters. The lengths of sound waves range from about 2 cm to 20 meters between peaks (or crests). (3) frequency (f): the frequency of any wave motion is the rate of vibration of its source, i.e., the number of waves sent out by the source per unit of time, or the number of waves which pass a given point per unit of time. The relationship between wavelength and frequency is inverse, i.e., the longest wavelengths correspond to the lowest frequencies and the shortest wavelengths to the highest frequencies. If all the waves are traveling through space at the same velocity, then it becomes obvious that more waves of shorter wavelength will pass a given point in the same amount of time, say a second, than will waves of longer wavelength. Therefore, speed = wavelength x frequency. (4) amplitude: the height of the wave crest above a line bisecting the wave crest and the wave trough. Amplitude is measured in ordinary length units. In sound, amplitude variations register in our ears as variations in loudness. With light, differences in amplitude are seen as differences in brightness; thus, the greater the wave amplitude, the brighter the light. (5) period: the period of a wave motion may be defined either as the time required for one wave to pass a given point or as the time required for the source to complete one vibration. The formula for period is: period = 1/ frequency. Let's see if this example will help: We are standing beside the opening of a tunnel as a freight train is emerging from it. As we observe the tunnel opening, ten freight cars emerge from it every minute. Therefore, the frequency is ten cars per minute, and the period is one tenth of a minute, which is equal to the reciprocal (the quotient of unity, or one, divided by any quantity) of the frequency. This is to say, the period tells us the time of one wave motion as being a percentage of the wave frequency. In terms of freight cars, one car = a period of one-tenth.

In terms of energy, the shorter the wavelength (hence the greater the frequency as more wavelengths will pass the given point in a second), the greater is the energy of that radiation.

The values of visible light wavelengths, actually a small band of the much larger electromagnetic spectrum or continuum, are: The size of the light wavelength is about 500,000th of a centimeter. Visible light waves vibrate up and down about 500 trillion times a second. One angstrom unit = 10-8 cm. One nanosecond of time is one billionth of a second. A "jiffy" = 1043 jiffies to the second, a duration of time so short that even light can only travel a mere million-billion-billion-billionth of a centimeter of space in one jiffy, a full 20 powers of ten smaller than an atomic nucleus. (Davies, P., Other Worlds. N.Y.: Simon and Schuster 1980; p.95).

Visible light is found between 4,000 to 7,700 angstroms, or the visible band is between 4 x 10-7 to 7 x 10-7 wavelengths in meters, or 3.8 x 10-5 (violet) to 7.8 x 10-5 (red) cm. Red light has a wavelength of 0.00007 cm or 700 nm, which corresponds to a frequency of 4.3 x 1014 oscillations per second; violet to 7.5 x 1014 oscillations per second.