Nyquist, Planck, and
The Particle Theory of Light

Characteristics of a Wave

The traditional way to describe a wave is to use its amplitude and frequency. The instantaneous magnitude of a wave is given by:

$a = A \sin 2\pi f t$

There are only two parameters I this equation. 'A' is the maximum value and 'f' is the frequency. 'a' is the magnitude at time t.

Characteristics of the Particle Theory of Light

While the wave equation above has two parameters, the particle theory of light has three. They are the Intensity, amplitude, and the frequency. The intensity is the number of particles per wavelength or its linear density. The amplitude is determined by the variation of particle density. The frequency is the number of times the density variation occurs per second.

Continuous vs Quantized

The wave equation describes a continuous wave. The Particle theory of light (PTL) describes a discontinuous wave. It is a coding scheme that samples the wave in very small intervals and assigns it a value. If we count the number of particles during the small interval, we might get a pattern like this:

(55, 60, 70, 60, 55, 45, 40, 30, 40, 45); all in one second

This wave has intensity proportional to 500 particles; has amplitude of 20 particles, and a frequency of one cycle per second. The amplitude of a sine wave is represented as +/- A. This is often interpreted as a push and a pull. The PTL clearly shows that all the particles push, but with different intensities (probability).

The Nyquist Sampling Theory

The Nyquist sampling theory states that an analog wave form can be digitized if the sampling rate is twice the highest frequency of the analog signal. Back in the mid-seventies I was involved with the development of a codec (coder/decoder) to convert analog voice signals to digital PCM (Pulse Code Modulation). The telephone industry knew that the highest frequency of voice was less than 4000Hz. Nyquist sampling theory states that the voice signal must be sampled at the rate of 8000 samples per second to allow the PCM code to reproduce the voice signal. Your cellphone uses a codec to convert your analog voice to PCM and transmit it over the voice network in packets. It also receives PCM code and coverts it back to analog voice so you can hear it.

Gamma Rays

Gamma rays have a very high frequency and a very short wave length. The wave length of a gamma ray is about 10^{-12} meters, while its frequency is 3×10^{20} cycles per second. You can see that the wave length times the frequency is the same as the speed of light. There must be enough particles in one wave length (10^{-12} meters) to be able to recognize the gamma ray. The sampling rate must be twice the highest frequency or $6x10^{20}$ samples per second. It only takes 2 samples per wave to know what the frequency is.

Even though the sampling rate must be two, there must be more than two particles. To get the amplitude, there must be many more. In the above example there are 100 per wave. If 100 were needed, then the minimum particle density for gamma rays would be 100 particles per 10^{-12} meters or $1x10^{14}$ particles per meter. That is all Nyquist says that you need, but more would be better.

Radio Waves

At the other end of the EM spectrum you have radio waves. Applying Nyquist's theory to a radio wave that has a wave length of 1000 meters and 100 particles per meter, then the particle density is 0.1 particles per meter. More is better.

Gravity

If gravity is caused by the same particle, it has a very low frequency and very low particle density. After all, it is the weakest of all the forces.

Intensity

In the particle theory of light, the number of particles per wave determines the intensity. Visible light from the sun has a high enough particle density that it can damage your eye. Visible light, reflecting from an object, has a reduced intensity and does not damage our eye. The frequency remains, even with a reduced number of particles as long as the Nyquist theory is maintained.

It was Planck that stated that the energy of light is proportional to its frequency. This is his equation:

$E = hf$; where:

h is Planck's constant

And Energy is quantized, but the equation does not show it.

Energy can be interpreted as intensity and intensity is determined by particle density. The higher frequencies need more particles to establish the frequency and as a consequence they have more energy. The lower frequencies need fewer particles to establish the frequency and hence can have lower energy. To re-state:

$I \propto N_p/\lambda$; and since:

$v_L = f\lambda$; Therefore:

$I \propto \frac{N_p}{V_l} f$, where intensity is quantized because N_p is an integer.

This indicates that Planck's constant is not a constant! It depends on the number and velocity of particles.

Bob de Hilster, 7/9/2015