Light Essay, Research Paper

Light is what we see. It can be thought of either as a particle, (the photon), or as a wave. The photon we can easily think of as a small dot travelling through space at the speed of light. Each photon has a particular colour or energy. But how do we think of light as a wave? For this we need to know that light is also an “Electro-magnetic field” — a combination of electric-field and magnetic-field — the same thing that causes static electricity and magnets to attract (or repel) things. Light is just another way that this “field” is experienced. A light wave is an oscillating electro-magnetic field – just like a water wave is water with an oscillating surface. Photons are bosons, and have a quantum spin of 1.

Light has the properties of both particle and waves. If we look for photons we will find them, but if we look for wave -like properties we can see them too. However, we cannot see both particle and wave properties at the same time.

It is often useful to confine light in an optical-cavity. This allows us both to make more intense light, as well as select light of a particular colour (or energy).

Light travels at a speed of 2.99792458×10^{8} ms^{-1}

When passing though matter, light is slowed down by brief interactions, and so appears to travel more slowly.

This “slowing down” is accounted for by the index of refraction of the matter.

Light’s properties can at first seem confusing and inconsistent because of

the unique nature of light: light has the properties of both a wave and a

particle. In some situations, light’s behavior is more easily explained by

thinking of light as a particle. In other situations, its behavior can only be

explained if light is thought of as a wave. This duality of light between a

particle and a wave is very difficult if not impossible to visualize. Instead

it is much easier to see light demonstrate its properties in specific

situations.

Light as a Wave

Before the nineteenth century, the physics community was split over the

actual nature of light. Around 1800, Thomas Young devised an experiment

designed specifically to settle the debate over the nature of light once and

for all. The basic principle behind the experiment was how light would

behave when it encountered an obstacle with a hole that was smaller than

the beam of light. Young set up a beam of light to shine through a slit,

then the resulting light that made it through that slit was to pass through

two more slits side by side.

If light behaves as a particle, it should pass through the first slit, then

through the two small slits. But, it should not spread out after passing

through the slits. Because of this if light behaves as a particle in this

situation, only two stripes of light should end up passing through the

entire slit system. The diagram below shows light behaving as a particle in

Young’s experiment.

These results were not what Young actually observed. Instead of seeing

two stripes, Young saw a series of many stripes. This was definitely not

consistent with the behavior of a particle. However, it was consistent with

the behavior of a wave. When a wave passes through a slit, it spreads out

on the other side. Also, when two waves pass over each other they can

interfere with each other. These two properties of waves explain the

behavior that Young observed. When the light waves pass through the slit,

the waves spread out on the other side of the slit. When the two waves overlap, they interfere with each other.

Dualities

Despite Young’s findings, many other experiments have supported the

theory that light exists as a particle. Max Planck’s investigation into black

body radiation could not be explained while light was thought to be a

wave. Planck began to develop the idea of packets of light called photons.

The idea of light being a particle was further developed by Einstein for his

work on the photoelectric effect. This duality causes light to be very

difficult for most people to visualize. Thinking of light as being a particle

at times and also a wave at times is the only way to understand light’s

diverse properties.

In modern physics, light or electromagnetic radiation may be viewed in one of two complementary ways: as a wave in an abstract electromagnetic field, or as a stream of massless particles called photons. Although either is an acceptable description of light, for our purposes in introductory astronomy the wave description will be more useful.

The speed of light in a vacuum is commonly given the symbol c. It is a universal constant that has the value

c = 3 x 1010 cm/second

The speed of light in a medium is generally less than this. Normally the term “speed of

light”, without further qualification, refers to the speed in a vacuum.