

Light

Light is a Wave

Light is refracted in lenses and reflected by mirror. Also, two fingers close together causes lines of darkness in between: destructive interference.
So, light must be a wave!



Light is a Particle

Light can travel thru the vacuum of space, but a wave can't travel in a vacuum. So *light must be a particle!*



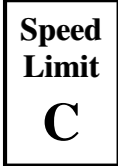
Light is Both

This contradiction perplexed scientists for many, many years, but the evidence must be believed: **light is both a wave and a particle.**

A light packet is called a photon.

Speed of Light = $c = 3 \times 10^8$ m/s

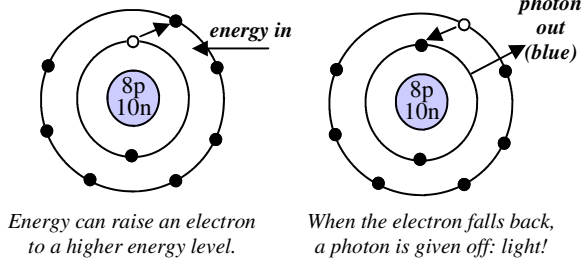
Sound is fast: 340 m/sec, in air, but **light is faster:** 3×10^8 m/s! That's 3 with 8 zeroes or 300,000,000 m/sec. Light can circle the earth 7.5 times in one second!



The speed of light is the ultimate speed limit.
Nothing can go faster than light.

Where Does Light Come From?

*Photons (light) come from electrons falling from high electron orbits to low orbits. These orbits are also called **energy levels**.*

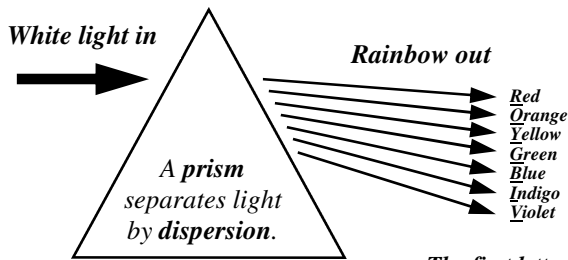


Because each element has a different number of protons, **each element** has slightly different electron energy levels and **gives off different colors.**

This fact allows us to tell the chemical makeup of stars. Just by looking at the light it gives off (its spectrum) scientist know the elements in the star.

Visible Light

White light is actually made up of many different colors, each with a different wavelength and frequency.



Different wavelengths (colors) refract (bend) differently when passing into glass. A prism's double refraction makes this more obvious.

The first letters spell: ROY – G – BIV

Colors have Different Energies

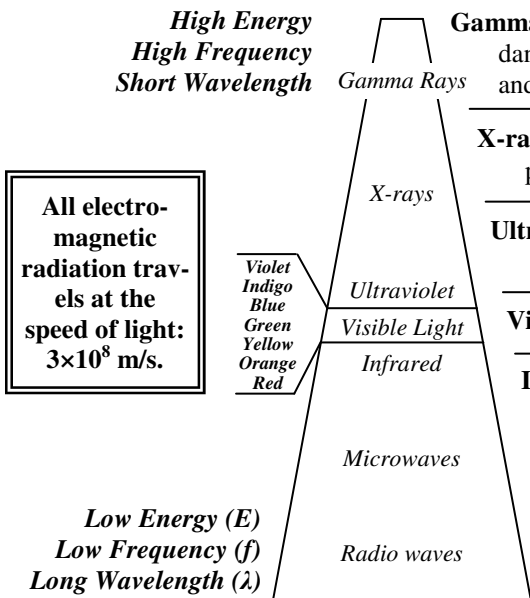


You know that different color flames give off different amounts of heat. Red flames are the coolest and blue flames are the hottest. *As you move from Red to Blue, light GAINS energy.*

White light is made up of all colors. That is why a white flame is the hottest!

Electromagnetic (EM) Spectrum

“Light” waves are electromagnetic radiation and includes ALL light: visible and invisible.



Gamma rays ($\lambda =$ less than .01 nm [a billionth of a meter]) – the most powerful and dangerous form of radiation. Emitted by nuclear reactions, they can break chemical and nuclear bonds and cause mutations.

X-rays ($\lambda =$.01 nm to 10 nm) – Used in medicine and industry because they can penetrate materials and tissues. Too much can cause mutations or tissue damage.

Ultraviolet light ($\lambda =$ 10 to 400 nm) – just above visible light; causes sunburns and skin cancer. The ozone layer protects us from most of the sun's ultraviolet light.

Visible light ($\lambda =$ 400 to 700 nm) – The smallest part of the EM spectrum.

Infrared ($\lambda =$ 1mm to 700 nm)– invisible red light radiation: what most people think of as heat. Can be seen by infrared cameras and goggles.

Microwaves ($\lambda =$ 1mm to 30cm)– used to cook food and for cell phones.

Radio waves ($\lambda =$ less than a cm to hundreds of meters) – very long, low energy waves used to transmit radio and television signals. Radio towers have to be so tall so they can long radio waves.

1. Photon	A. the speed of light and the fastest speed in the universe.	1. Radio waves	A. Electromagnetic waves we feel as heat.
2. 3×10^8 m/sec	B. Also known as an electron orbit. To move from low to high requires energy.	2. Infrared	B. Dangerous EM waves that have very high energy and come from nuclear reactions.
3. Prism	C. All light: visible and invisible.	3. Ultraviolet	C. EM waves that have very low energy and long wavelengths.
4. Light	D. Uses dispersion to separate white light into its colors.	4. X-rays	D. EM waves that can pass through skin and have short wavelengths.
5. EM Spectrum	E. A single particle or packet of light.	5. Gamma rays	E. EM waves with more energy than visible light and can cause sunburns.
6. Energy Level	F. A wave that can travel through a vacuum.	6. Microwaves	F. Long wavelengths; used in cell phones.

Is light a wave or a particle? Prove your answer:

Put these three in order from slowest to fastest:
Light waves; sound waves; water waves.

Where does light come from?

Put these from shortest to longest wavelengths
Radio waves Ultraviolet X-rays Visible Microwaves

Find the period of a 10 Hz wave.

Put these from least energy to most energy.
Radio waves Ultraviolet X-rays Visible Microwaves

A wave has these characteristics: 25 Hz and 8 m. Find speed.

Why do we see lightning and hear the thunder a few seconds later?

A sound changes from 25 dB to 5 dB. How much louder does the 25 dB seem to us?

You hear a thunder 3 seconds after you see the lightning. How far away is the storm?

You are in a concert hall and yell up to the ceiling. It takes 1 second for the echo to come back to you.
A) 1 second—is that the time for the sound to go to the ceiling or for the sound to go to the ceiling and back?
B) If you want to know how high the ceiling is, how long does it take for the sound to get to the ceiling?
C) Find the how high the ceiling is.

Find its period: _____

What harmonic is this? _____


Mark the nodes and anti-nodes.

Mark one wavelength on the harmonic.

Can humans hear this frequency? _____

Find the fundamental frequency:

3rd harmonic frequency:



40 Hz