

# Glowing Objects, Radio Waves, Lasers, and Photons

Glowing objects, radio waves and lasers all emit photons. So what is the difference between them?

## Light from Glowing Objects

The photons from glowing objects are randomly emitted by hot atoms where electrons are changing from a higher energy level to a lower energy level. The energy lost by each electron becomes the energy of an emitted photon.

Those photons are spread over a **very wide range of frequencies**, have **random polarizations**, and are **emitted in all directions**. They are **incoherent** which means they have no relation to each other and act independently on a receiving surface. The radiation of glowing objects is called “black-body” radiation because they absorb and emit radiation with perfect efficiency similar to how ideal black objects absorb and emit electromagnetic radiation. In contrast, radiation from shiny, reflective surfaces glow with different efficiencies that depend on the details of their surface characteristics.

## Electromagnetic Waves from Radio Antennas

A radio antenna has electrons moving back and forth at a **particular frequency**. The accelerating electrons emit photons which are launched with that frequency in **range of directions and polarization determined by the shape of the antenna**. Generally, radio wave photons are at a frequency about a million times lower than visible light photons. Since photon energies are proportional to their frequency, radio wave photons are a million times weaker than visible light photons. Nevertheless, there are an enormous number of them and they are all working in a **coherent** manner. They are therefore able to work in unison to move electrons in a distant receiving antenna.

## Lasers

Lasers have photons that have **nearly identical frequencies, polarizations, and directions**. Furthermore, they are **coherent** like radio waves. A laser has a method of raising many atoms to a higher energy level from which they cannot easily drop down to a lower energy without some stimulation. The letters of the word **laser** represent **light amplification by stimulated emission of radiation**.

Normally, atoms in a raised energy level emit a photon in an amount of time determined by many factors, but those at elevated levels in a laser are normally especially slow to drop to lower energies and emit photons. Einstein showed that electrons in energized atoms can be stimulated to emit photons quickly if they feel a passing photon of a frequency that perfectly matches an energy difference to an available lower energy level. In that case, they will emit a photon that not only matches the frequency of the passing photon, but also matches its direction, polarization, and phase. Then, two identical photons are passing along the length of the laser which can in turn stimulate the emission of more identical photons until a very large number of identical (**coherent**) photons are moving out the end of the laser. This growth in the number of photons happens exponentially like an explosion. Basically, laser light is like a radio wave at light frequencies.

There are also microwave devices called masers (**microwave amplification by stimulated emission of radiation**) which were actually invented first.