The Science Behind UV: Understanding Black Light

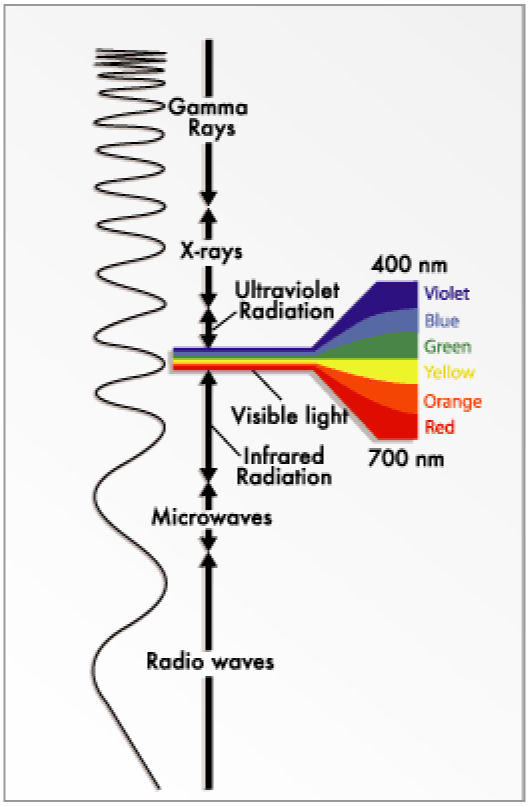
What you need to know about black light in order to create spectacular, ultra-bright black light effects.

Black light is the common name for long-wave ultraviolet light (or UV light for short). Don't worry. We'll get to what exactly that means in a minute. For now, understand that UV light is just like visible light, except it has more energy. And you can't see it.

Visible light and UV light are forms of energy known as electromagnetic energy. So are radio waves, microwaves, x-rays, and gamma rays. There is a whole spectrum of electromagnetic energy that encompasses a very wide range of energy levels.

Electromagnetic energy, like its name suggests, has both electrical and magnetic properties. But the really interesting thing about light is its dual nature: it sometimes behaves as a wave, and sometimes as a particle. It just depends on how you look at it, or how you study it.

In defining UV light, we'll be thinking of those wave properties and will talk in terms of *wavelength.* In the tutorial on fluorescence, we'll be looking at the particle nature of light.



Low energy light waves have very long wavelengths. Radio waves, for instance, can have wavelengths many miles long. Because they are low in energy, they are harmless to humans and pass through our bodies all the time without us being aware.

Conversely, very-high energy light waves have extremely *short* wavelengths, which can be much smaller than the diameter of an atom. Gamma rays and x-rays are examples of high-energy electromagnetic energy. They are deadly to all life, and even exposure to very low intensities is known to cause cancer.

Visible light is right in the middle of the spectrum—more energetic than radio waves, but not so energetic as to be harmful. (Microwaves have longer wavelengths, and lower energy levels than visible light. However, particular frequencies—those used in microwave ovens—*are* dangerous because they cause water molecules to vibrate and heat up.)

Wavelengths of electromagnetic energy between roughly 400 and 700nm (nm = nanometers, or *one billionth* of a meter) are visible to the human eye. The longer wavelengths—toward 700nm—are on the lower end of the visible spectrum, while the shorter wavelengths—toward 400nm—are on the upper end of the spectrum.

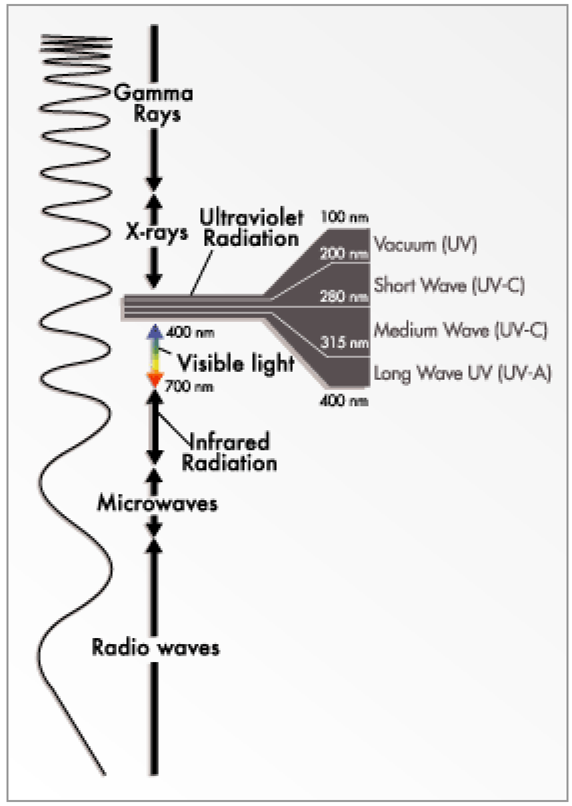
The visible spectrum is divided into the different colors we see. Red is on the low end, with longer wavelengths, while violet is on the high end, with shorter wavelengths. You may have taken a science class where you had to memorize the spectrum of visible colors: ROYGBIV. As you progress up the visible spectrum, you see a shift in color from Red to Orange to Yellow to Green to Blue to Indigo to Violet.

Beyond violet—just beyond what the human eye can see—is ultraviolet light. Although we can't see ultraviolet light, certain birds, reptiles, and insects such as bees are able to see it. Imagine being able to see another "color!" It would open up a whole new world!

Ultraviolet Light Range

Ultraviolet light is really a broad name given to a range of wavelengths from around 100 to 400nm. UV light with wavelengths shorter than 200nm exists only in vacuum, since they are quickly absorbed by air or water molecules. This range is known as vacuum UV.

The other wavelengths, from 200 to 400nm, are broken up into three bands: **long-wave UV**, **medium-wave UV**, and **short-wave UV**.



The **short-wave UV** range, also known as UV-C, is from around 200 to 280nm. Short-wave UV is very dangerous and will cause severe burns. Staring straight into a light source emitting this range will cause blindness. Bacteria and other germs don't stand a chance—which is why this range is so useful for germicidal applications. Short-wave UV at 254nm is often used to purify air, water, and food because it kills 99.9% of all pathogens. Fortunately for all of us on earth, short-wave UV from the sun is completely absorbed by the upper atmosphere.

The **medium-wave UV** range is less energetic than short-wave, but still harmful to humans. Medium-wave UV, or UV-B, is defined as having wavelengths between 280 and 315nm. This is the range that is responsible for sunburn...but also skin tanning. The lights used in tanning salons produce medium-wave UV light. However, prolonged exposure to medium-wave UV is believed to cause skin cancer, though there has been some recent controversy over whether this is entirely true.

Long-wave UV, or UV-A, is the kind used in entertainment applications. This is what's known as "black" light. ("Black" because you can't see it.) In comparison to short-wave or medium-wave UV, long-wave UV is pretty safe. This range is defined by the wavelengths between 315 and 400nm. Remember that 400nm is about the extreme edge of visible light. So this range is just beyond what humans can see. So how is it we can see under black light? Well, there are two reasons.

1. Even artificial UV light sources don't emit *pure* UV light. Visible light is also present. Depending on the technology used and the manufacturer, there can be quite a bit of, or very little visible light emitted by the UV light fixture.

2. Even in the presence of pure UV light, you could potentially see a great deal. It would all depend on the degree of UV sensitivity of the materials around you. UV sensitive materials actually give off visible light themselves. And that brings us to the topic of fluorescence, which we'll discuss in the next tutorial…