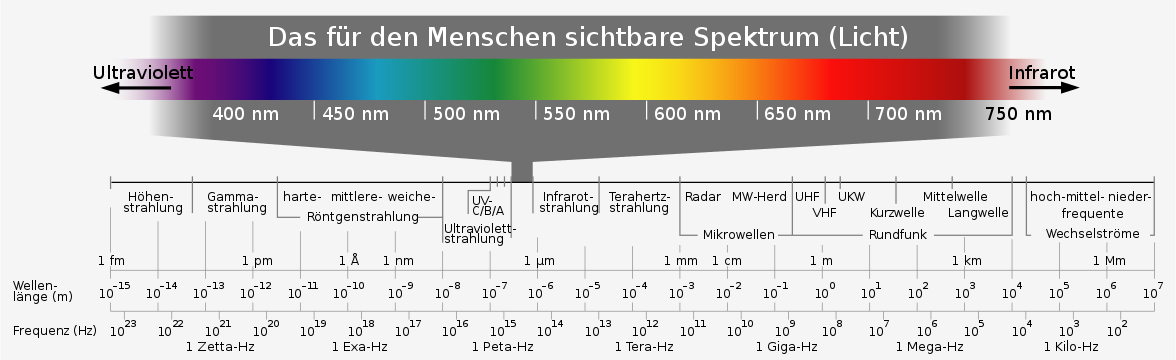
# The problem with the wave

Light, as we have seen, behaves like a wave when passing through a grid or a small hole. There are interferences, which means that in some places it becomes bright because wave peaks and troughs always arrive from different places at the same time. In other places it becomes dark. There, peaks meet troughs and troughs meet peaks like mountains meet valleys and valleys meet mountains.

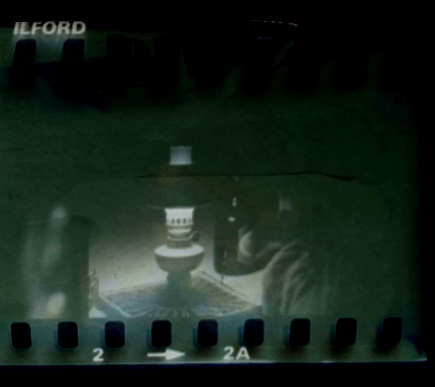
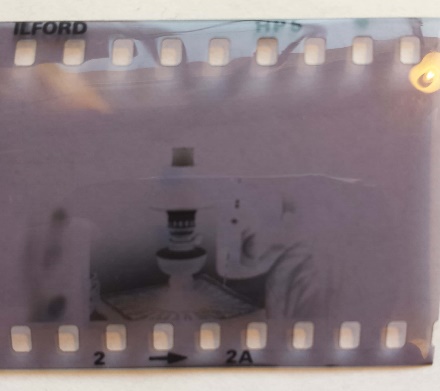
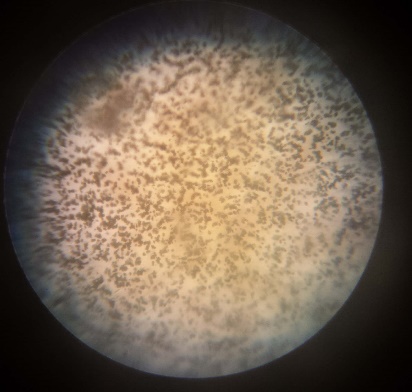
We have calculated the locations of the brightness of the 1st order with our tangent and sine formulas. Each color therefore has a different wavelength. Now nothing has been found in which the waves can exist except simply space, also empty space, i.e. vacuum.

It has been concluded that it is an electromagnetic wave, like radio waves but at an insanely high frequency, around 1,000,000,000,000,000 cycles per second (1015Hz).



**Figure 1: Spectrum of electromagnetic radiation**

Now there is a problem. If you look at a photographic negative through a microscope, you will see the following image on the left:



**Figure 2: left negative under the microscope, middle the negative, right with reversed brightness**

A black-and-white photo consists of nothing but small grains of silver in a layer of gelatine. They are so small that you cannot see them with the naked eye and appear black. In some very coarse-grained images, however, they can also be seen with the naked eye. They were taken in low light.

Silver bromide or silver chloride is present on the film. This is light sensitive. If a film is exposed, the silver bromide is sporadically decomposed at the bright spots and silver is separated out. And the brighter it is, the more so. The silver grains are much too small at first, if the film is not yet developed you will not see anything unless you expose for hours. In the early days, people had to sit still for a long time with headrests. That was a test of patience.

Finally, developing was invented: More silver bromide is converted in the developer and the silver is deposited on the grains and these grow until they become increasingly black. Where it was light, the negative is now dark. In low light, there are few granules. You develop longer and the grains get bigger, but there are fewer: the image is grainy.

However, pure silver bromide is not decomposed by long-wavelength red light. Not even if you make it brighter and brighter. So-called panchromatic films were made sensitive to red and yellow-green light using special materials.

Why is there a problem with the wave? If you want a wave to have a stronger effect and transport more energy, you can simply make it larger. You increase the intensity. But this doesn't work with red light. In a darkroom for developing paper images, you can safely turn on red light. However, even the smallest intensities of blue light immediately darken the photo paper. Therefore, the localized effect of light depends on the wavelength. This localized effect is now called a photon.

Now we turn to a comparison: a model that has nothing to do with light at first, but behaves partly like it. A wave can wash away a house on the beach if it is made high enough. It depends on the intensity. Light doesn't do that. A single bullet can penetrate a wall if it is fast and heavy enough, even if it is small. Foam balls can't do that, even if you take a lot of them. So light behaves like a particle, weaker for red and stronger for blue, when it dissolves chemical bonds or releases electrons from metals. It acts like a small particle or corpuscle, a tiny particle. This is called particle nature. Now there are two models with different properties:

1. The wave during propagation
2. The particle during the effect

At first, this caused a lot of confusion. Which one is valid?

**Questions:**

* + 1. One type of film is just barely insensitive to yellow-green light. Which lamp colors are allowed for the darkroom?

a) red b) purple c) blue d) green e) yellow f) orange

* + 1. How does one conclude the particle nature of light in the example of film blackening?
    2. To what extent does a particle model contradict the wave model?
    3. Give a personal comment on the models.