Light and matter

Key words:

Light, visible, ultraviolet, infrared, absorption, spectrum, spectroscopy

Different sorts of light

Light is a type of energy. We call this type radiation or electromagnetic waves. The energy content of light can vary greatly. We call the band width of electromagnetic light the 'spectrum'. Our eyes are made in a way so that they can see a certain range of wavelenghts in this energy spectrum. If all wavelengths of sunlight reached our eyes at once we would see white light.

1. Spectrum of white light

However, white light is composed of various wavelengths. If we see them separately, they appear as colours. Each colour has a different wavelength and a different energy. Blue light is of higher energy than red light.

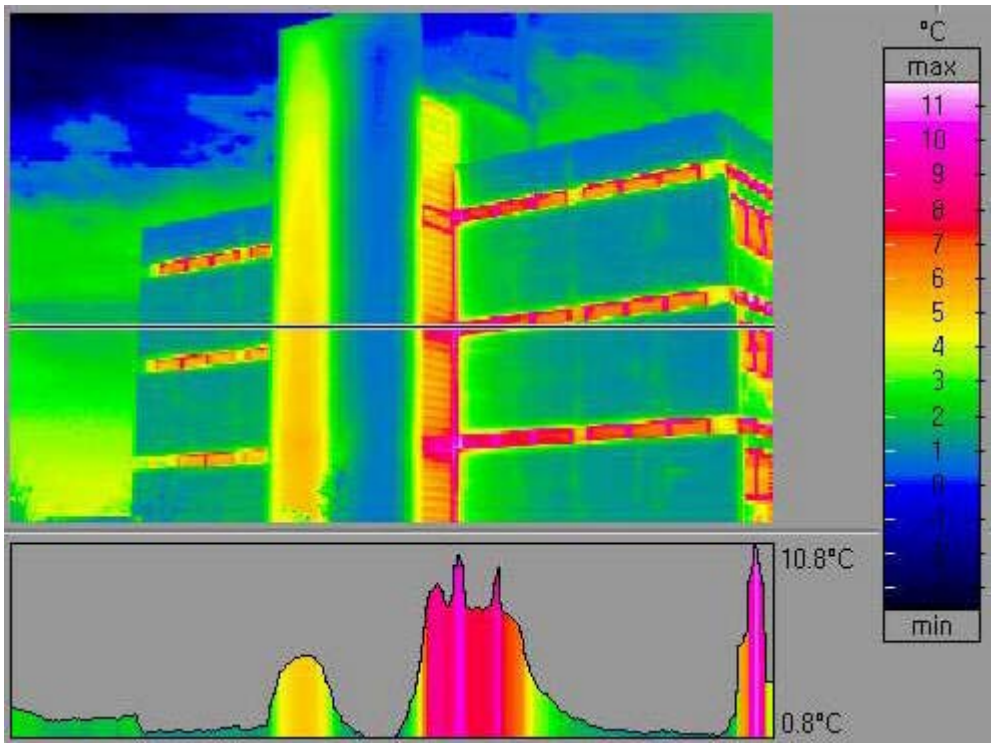
2. On a natural or artificial sunbed: In both cases invisible UV-light exerts an influence on our skin such as any sort of radiation has an influence on matter.

If we are lying in the sun for a long time it harms our skin. We get sunburn.
In artificially lit rooms this does not happen. Sunlight includes a certain sort of radiation which has a very high energy and changes the cells and molecules in our skin. We cannot see this damaging light because our eyes do not have receptors for it. This 'invisible light' has a higher energy than the blue and violet light we can see. This is why we call it 'ultraviolet' light.

We can make ultraviolet light visible for our eyes if we irradiate a chemical substance with UV-light which sends back visible light to our eyes, for example a screen made of zinc sulfide.

The spectrum of electronmagnetic waves also continues beyond the red light but this radiation has less energy. It does not harm our skin and we do not see it but we feel it as warmth. It is emitted for instance by a red-light lamp.

3. An infrared lamp emits the major part of its energy not as visible light but as invisible thermal radiation.



4. on the left: Thermal image of a school. Please click on the image in order to see the color legend and an enlarged photo. (40 K) © Emil-von-Behring-Gymnasium / Spardorf

Thermal cameras are instruments which see this sort of radiation. We 'translate' their information technically into colour images we are used to, symbolising warmer regions in red and colder regions in blue.

Absorption

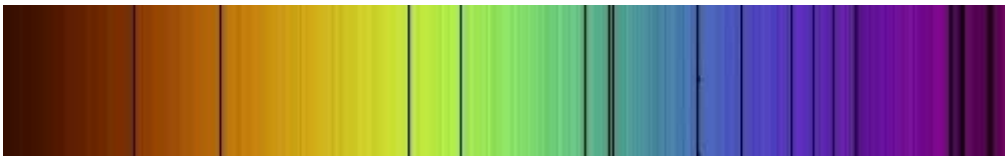
Light changes the state of matter. We see this from the influence of solar radiation on our skin. Matter (chemical compounds) in our environment can take up light of a certain wavelength. We call this absorption.
Let's imagine we take a prism and split up the white light of a lamp, which emits all spectral colors.

6. a) Spectrum of a light source emitting continuous light

Afterwards we may install the prism in a chamber filled with sodium steam. The sodium takes up light of a certain energy, which is missing in the spectrum. A dark bar appears.

6. b) Absorption by sodium vapour in the yellow region of the spectrum
Graph: Elmar Uherek

Fraunhofer Lines



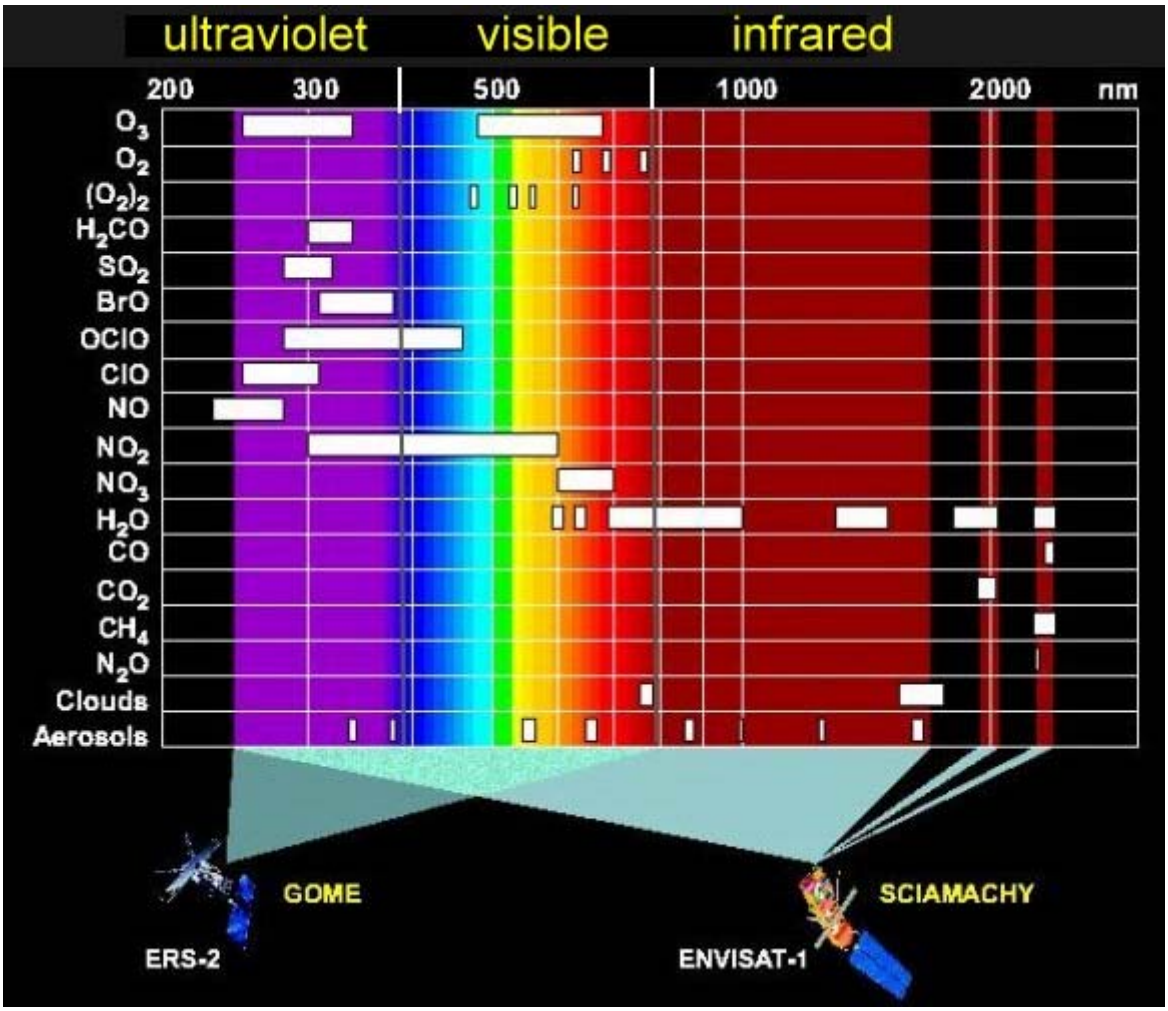
7. Fraunhofer lines - witnesses of the absorption in the atmosphere of the sun

If we study the spectrum of the sun in detail we see that there are some more black lines. We call them Fraunhofer lines. They are caused by the absorption of light in the atmosphere of the sun and tell us about the elements there.

8. A comparison of the sodium absorption and the Fraunhofer lines of the sun spectra shows: There must also be sodium vapour in the atmosphere of the sun.

Satellite measurements

Now we have an idea of how satellites observe the number of molecules of a chemical compound in the Earth's atmosphere. The instruments located on the satellites (spectrometers) register the fraction of the normal light which is absorbed by the molecules. This fraction is missing in the spectrum of the light reaching the instrument. The spectrometer described in the article "research", called SCIAMACHY, measures light in the ultraviolet, visible and infrared regions. Ozone primarily absorbs in the ultraviolet.



9. Measurement range of the spectrometer in the SCIAMACHY and GOME instruments © IUP Bremen