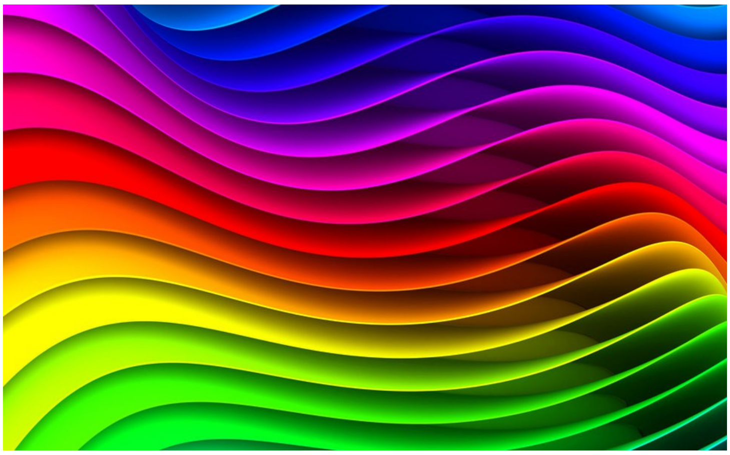
Theremino System

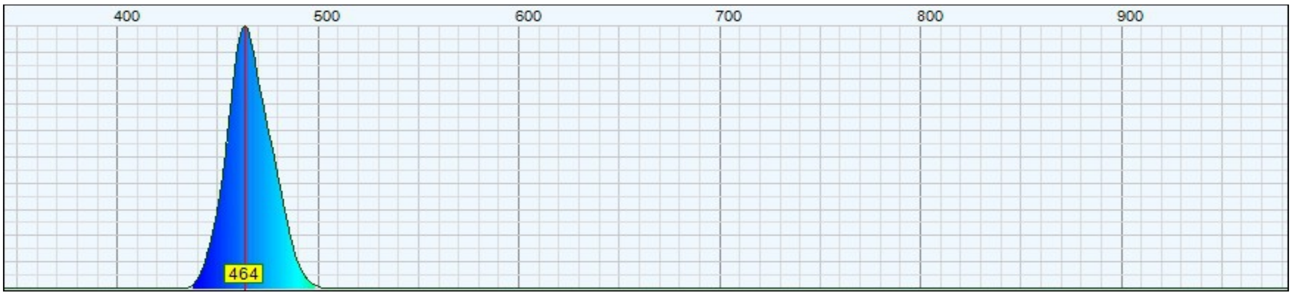


Theremino Spectrometer Sample Spectrums

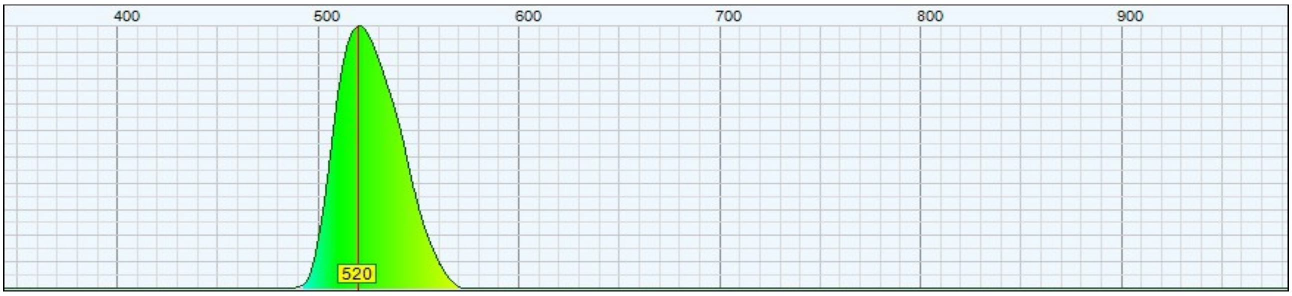
LED Spectrums

Ulltraviolet LED - 395 nm

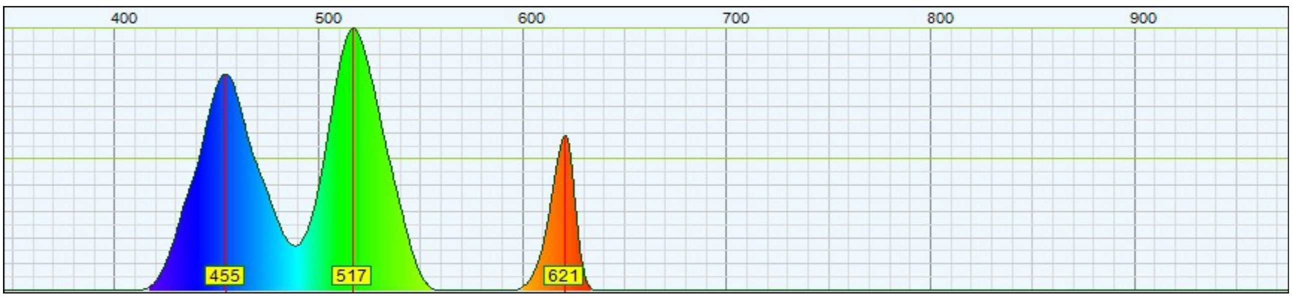
Ultraviolet LED - 407 nm (the best on the chlorophyll fluorescence of olive oil)



Blue LED

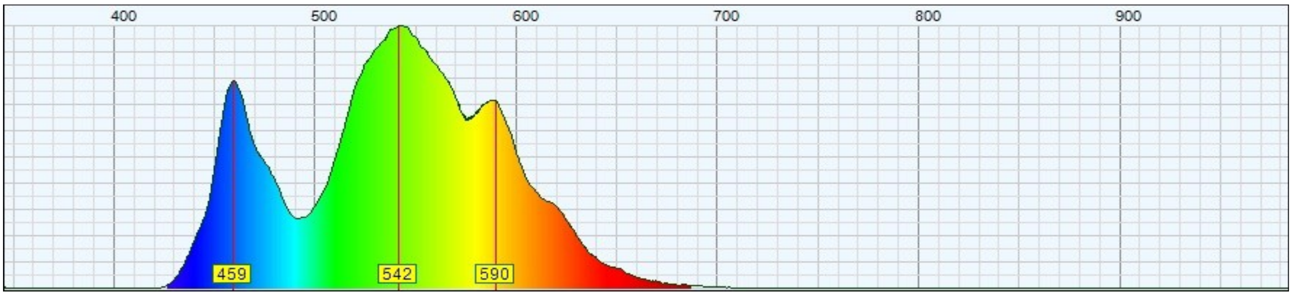


Green LED

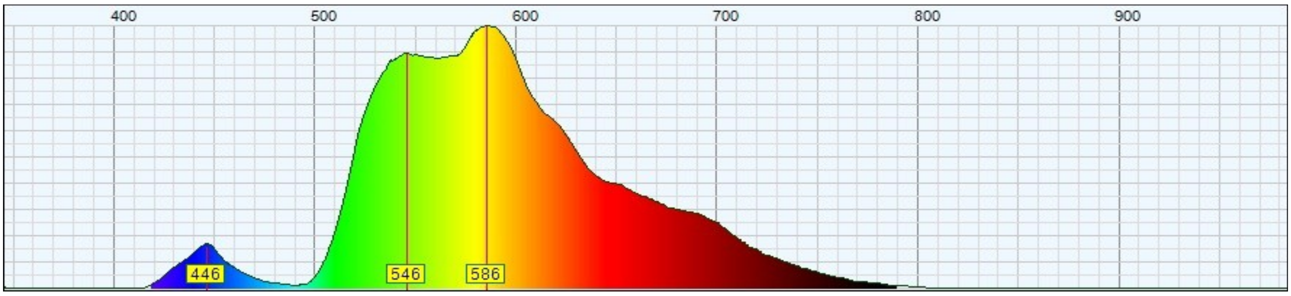


RGB LED (from led strip SMD 5050 trichip)

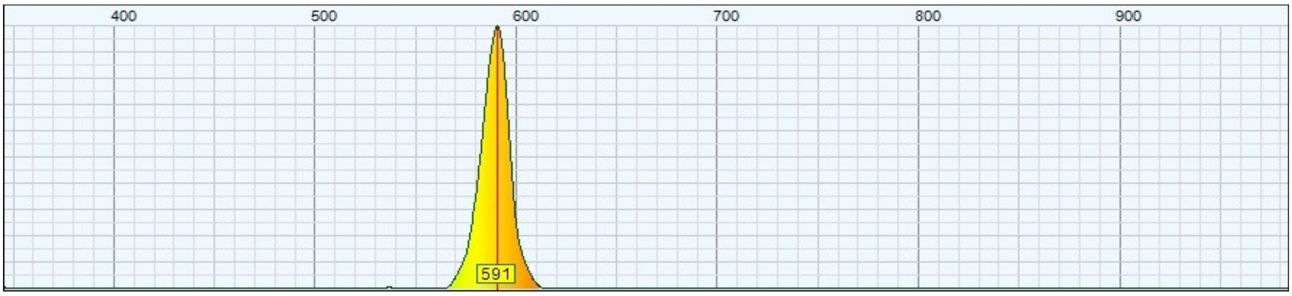
LED Spectrums



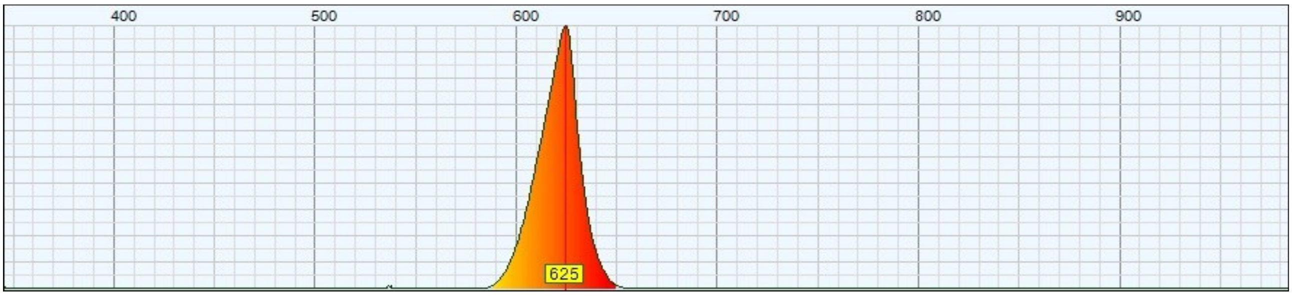
Cold White LED



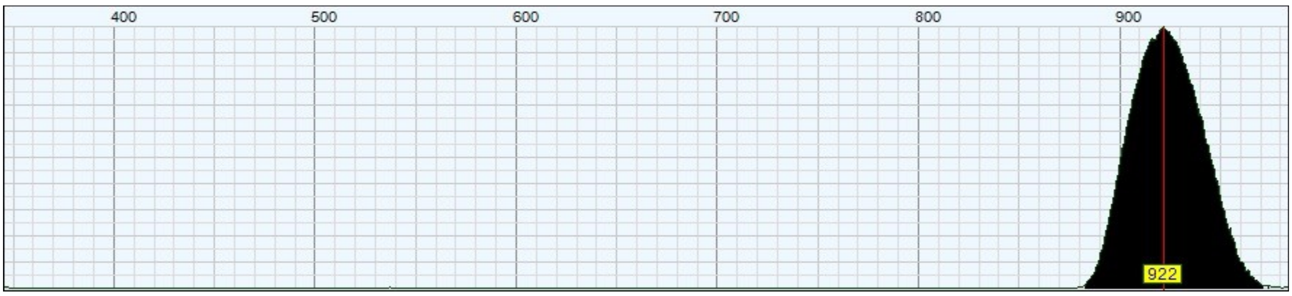
Warm White LED



Amber LED

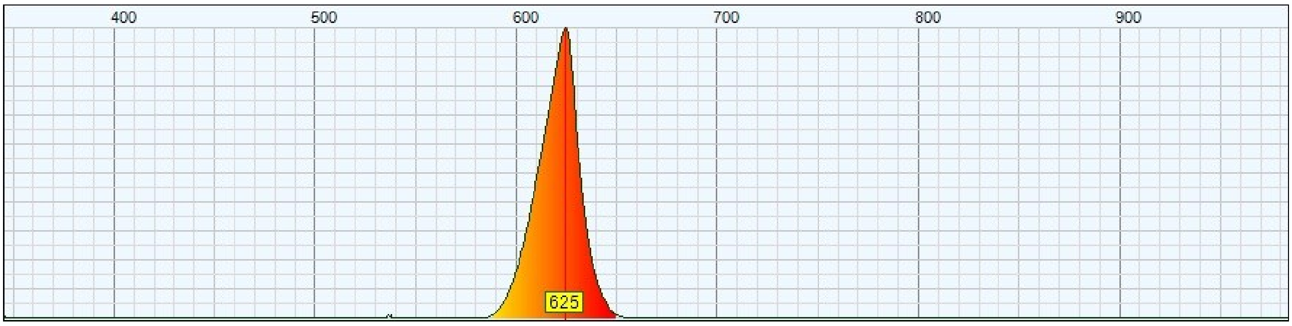


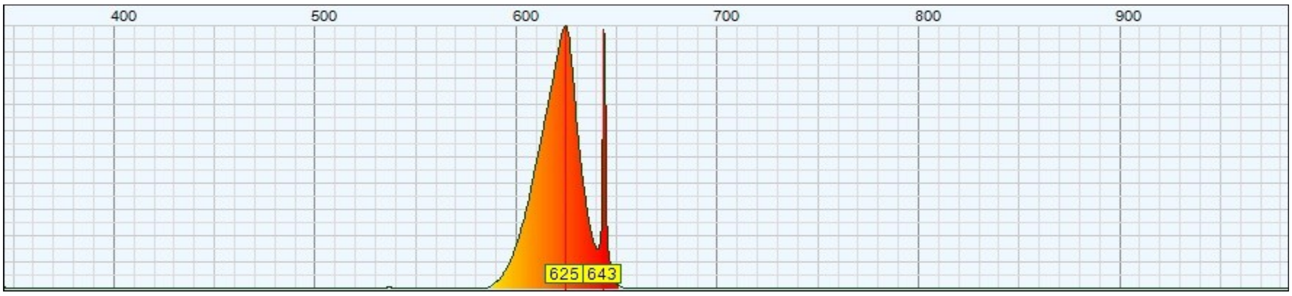
Red LED



Infrared LED

Comparison between LED and Laser





Red LED + Red Laser. Note the resolution of the laser line and the line of the red LED is not affected by the laser light, only a few nanometers away.

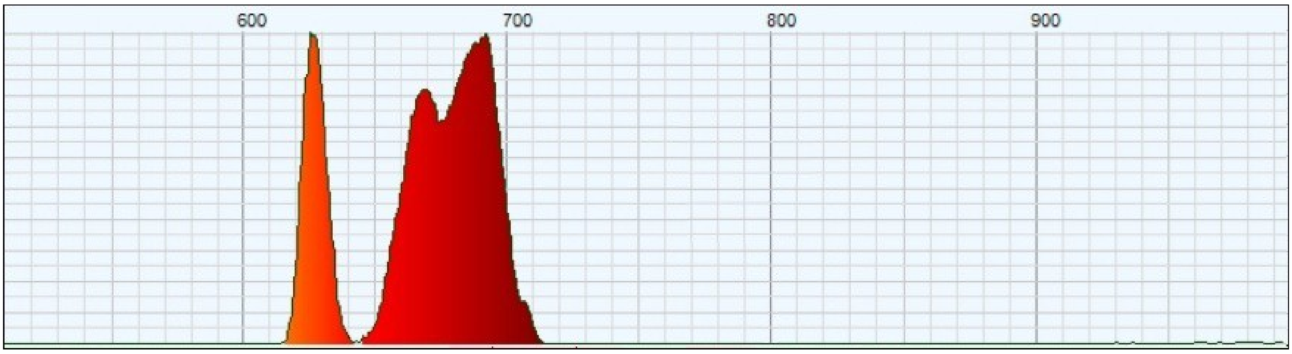
The wavelengths of the most common lasers

- **Violet laser** 405 nm (same wavelength discs "blu-ray" and led UV)
- **Blue Laser** 473 nm
- **Green lasers** 532 nm
- **Helium-neon laser** 633 nm
- **Red Laser** 635 nm (the most visible) and up to 640, 650 and 670 nm (the cheapest)
- **Infrared Laser** 808 nm (or 1064 nm with traces of 808 nm)

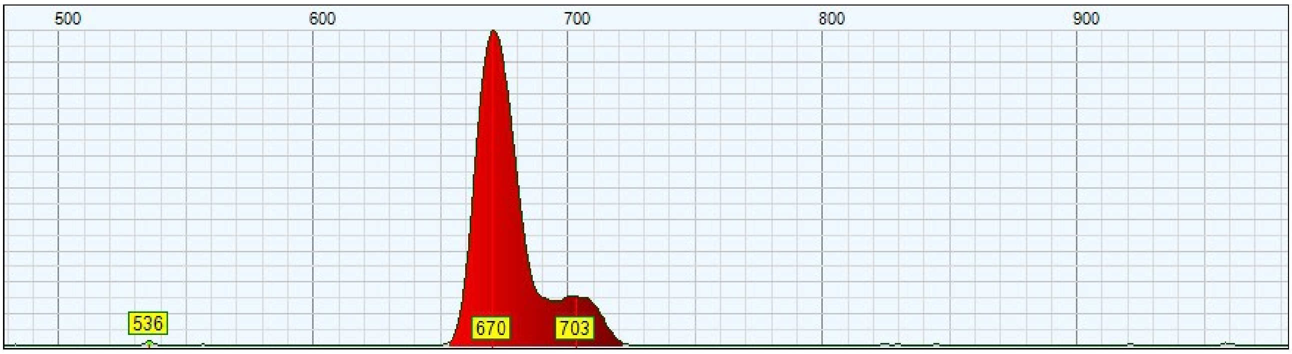
Fluorescence of some materials

The fluorescence of the following images was excited with a 407 nm ultraviolet LED.

Uranium glass



Eggshell (porphyrin)

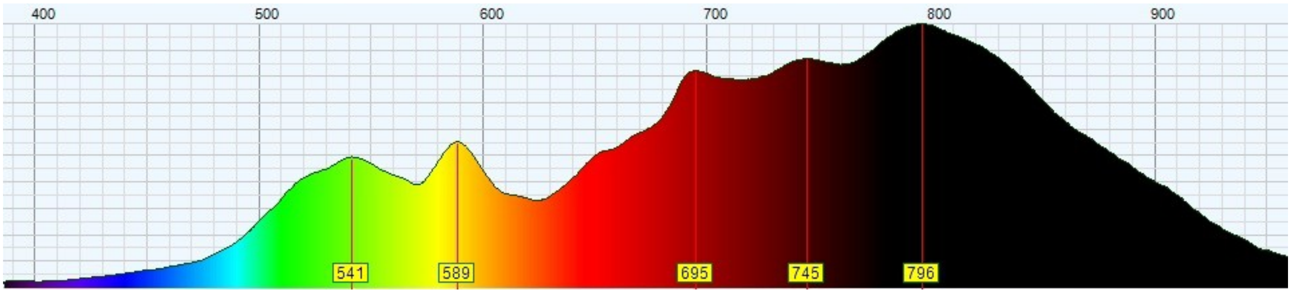


Extra virgin olive oil (chlorophyll)

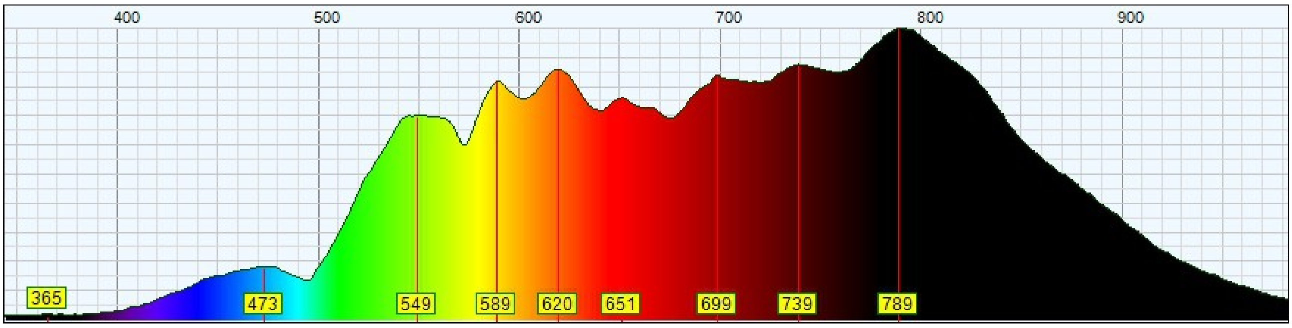
The chlorophyll fluorescence is explained in detail in the file "Theremino_OilMeter_TestMethods" which is part of the "Theremino Oil Meter" documentation.

The Theremino Oil Meter "is a olive oil tester, based on the measurement of the oil fluorescence and transmitted light, in the bands from 450 to 500 nm and from 650 to 700 nm. To develop the Oil Meter we had to choose the best color filters, LED and phototransistors. During this research the "Theremino Spectrometer" was essential and has allowed us to make a more reliable olive oil tester.

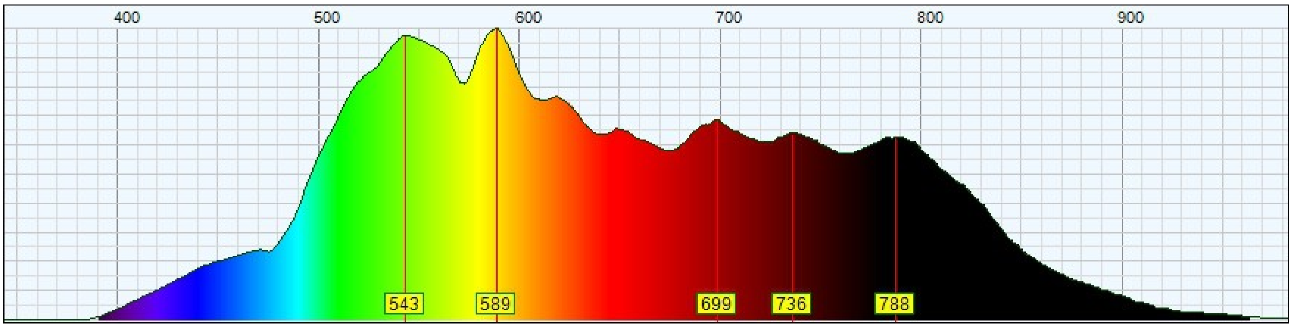
Filament Lamps



Small half-watt incandescent bulb (100 mA at 5 V)



Classic 100-Watt incandescent lamp

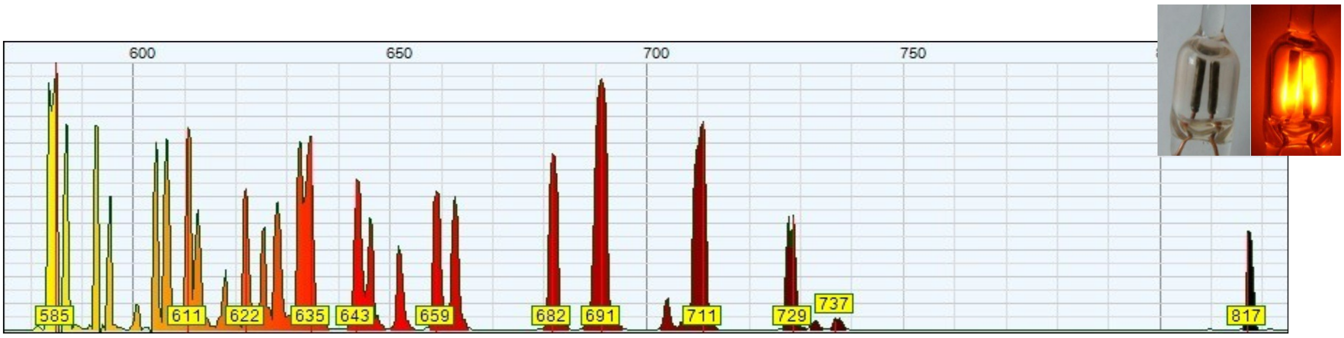


Halogen Bulb 50 Watt

Filament bulbs emit energy across the spectrum in the visible and infrared. The higher the temperature of the filament and the greater the production of visible light, compared to the light "wasted" in the area of the invisible infrared.

Halogen bulbs have a filament hotter and therefore emit less infrared.

Neon bulb



Small neon bulb.

The number of rows produced is incredible. Even with low light, the spectrometer is able to solve thirty lines.

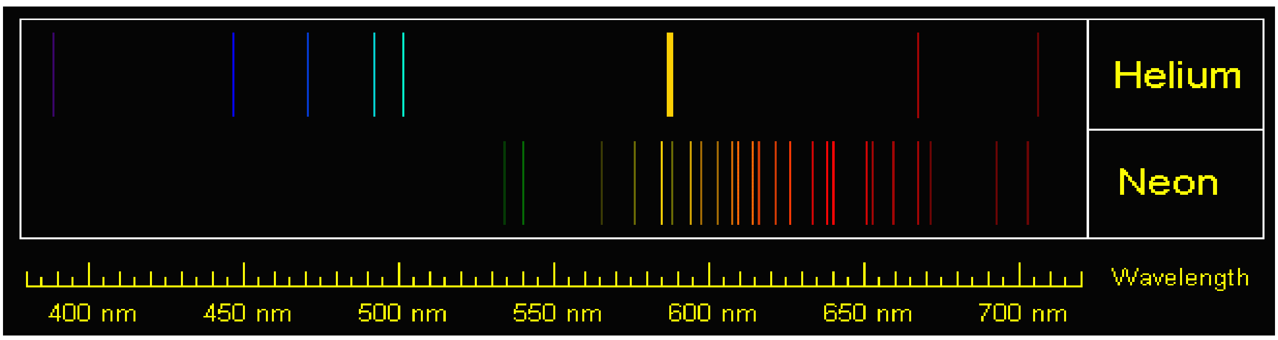
This is a simple neon bulb, but is also a plasma chamber that demonstrates the operation of electrons and atoms. The ionized plasma inside the light bulb emits only very specific wavelengths, with little or no emission between these lines. The mechanism of production of these spectral lines has been a mystery for many years. Then, in 1913, Niels Bohr explained it with a model of the atom in which the electrons orbiting the nucleus. In his model existed a certain number of electrons for each of the different elements, and these electrons have very specific energy levels.

When the element is heated, or electrically excited, electrons jump to a higher energy orbital, then falls to the initial level, emitting photons of light, to release the energy difference. The wavelength, or color, of the photons is the exact difference between the two energy levels. Since the visible lines are narrow, without energy values in the middle, it follows that there are only specific amount of energy for the orbits of atoms.

From these considerations and from this simple light bulb, were born the orbits of the electrons, the "quantums", the atoms as we know them today, and the whole quantum mechanics.

Other substances that produce lines

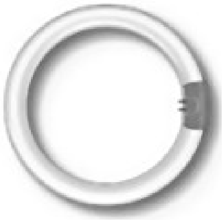
Not only does the neon but virtually all elements of the periodic table produce characteristic lines. The best known (used in lamps) are Helium, Neon, Argon, Krypton on, the Xenon, Mercury and Sodium.



Lines of Helium and Neon (rows theoretical, calculated according to quantum theory)

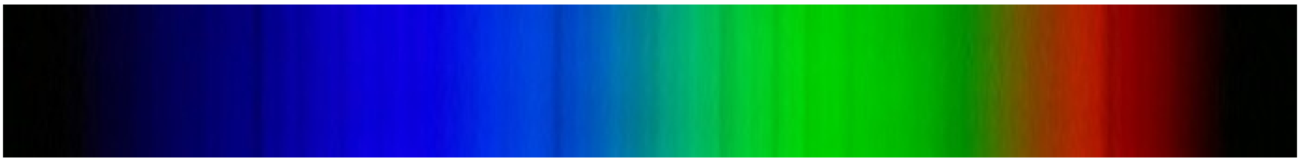
Fluorescent lamps

Fluorescent lamps are of various types: Fluorescent Tubes, Energy Saving Lamps (CFL - Compact Fluorescent Lamp) Lamps and Cold Cathode (CCFL - Cold Cathode Fluorescent Lamp)



All of these lamps have emission spectra similar to each other. They contain mercury, neon, argon and krypton, which produce some ultraviolet and blue, green and red rows. The white coating of fluorescent pigment, widens a bit these lines and produces a light that appears white to the human eye.

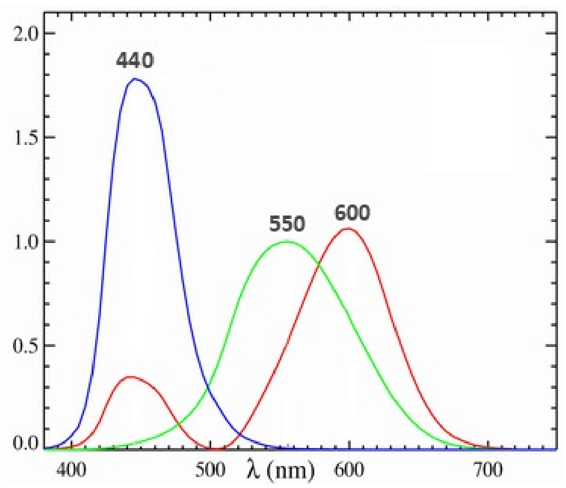
Fluorescent lamps, unlike the solar light, not emit all wavelengths, but concentrate their energy in some areas, called "characteristics emission lines".



Sunlight

Light of fluorescent lamps

Fluorescent lamps look white, because the human eye sees only three colors: blue, green and red, called "primary colors".



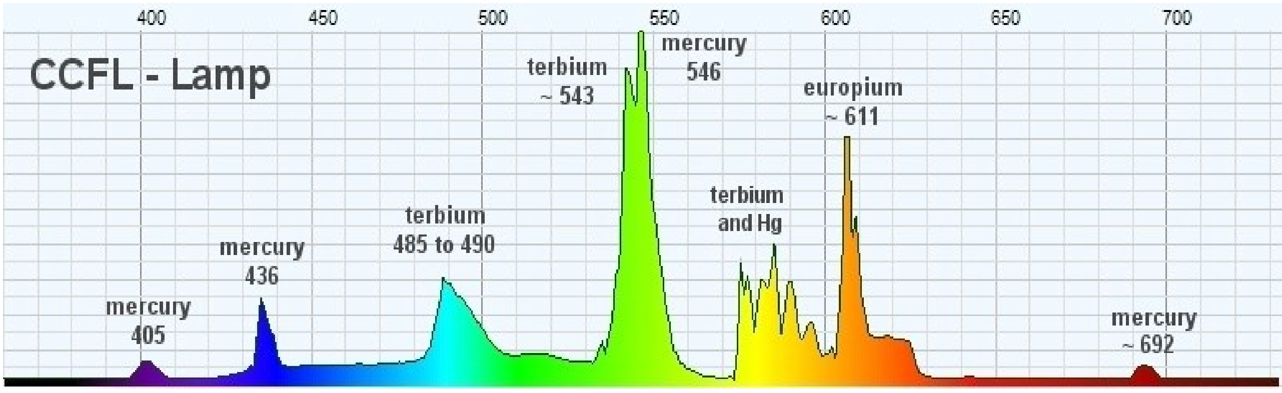
Response curve of the human eye

The eye receives and measure separately the three basic colors. A lamp is white, if it emits energy in the right proportions in these three areas.

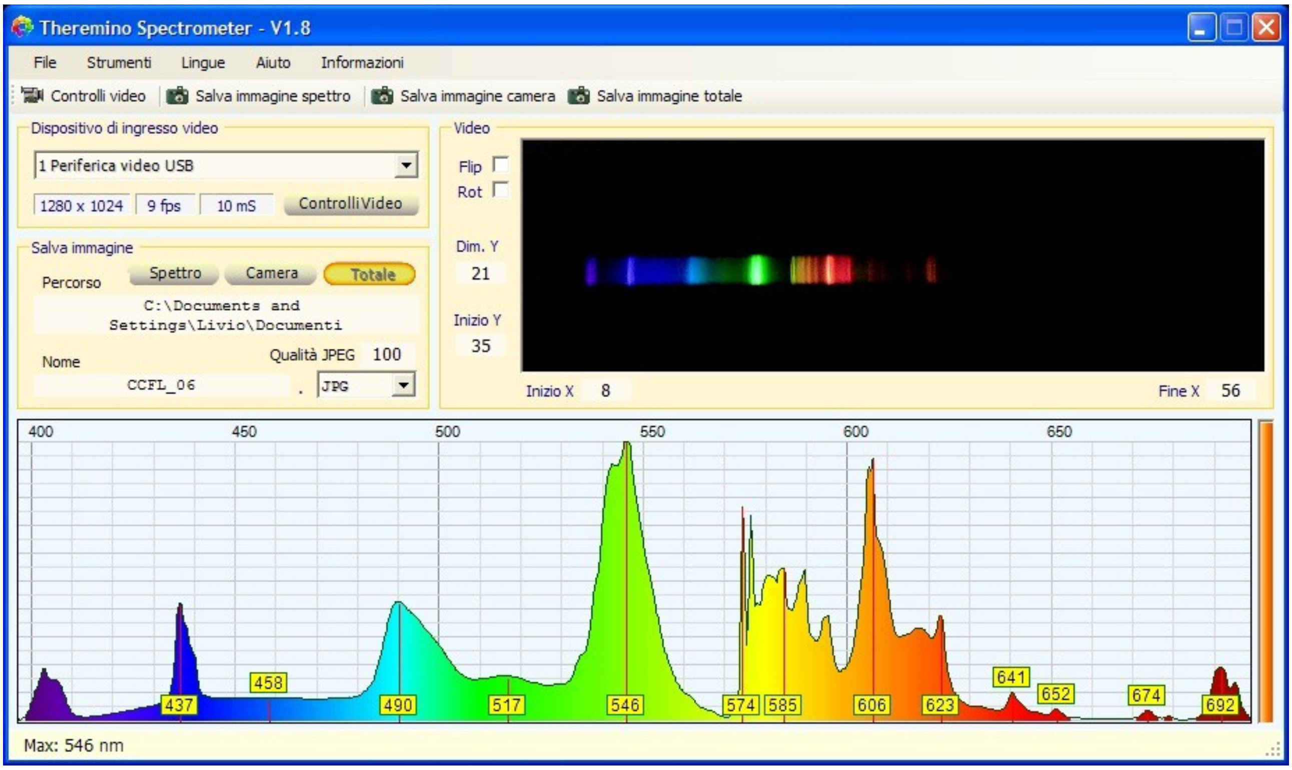
The intermediate colors are not actually visible, but are calculated by the nervous system, starting from these three colors. This implies that for the human eye an intermediate color (for example yellow) is indistinguishable from a right mix of green and red. A spectrometer on the other hand does not see the yellow, but the two, green and red, separated peaks.

Fluorescent lamps characteristic lines

The spectrum contains two fluorescent lamps lines useful for calibrating the spectrometer. The two characteristic wavelengths are those produced by mercury **436 nm** and to **546 nm**.



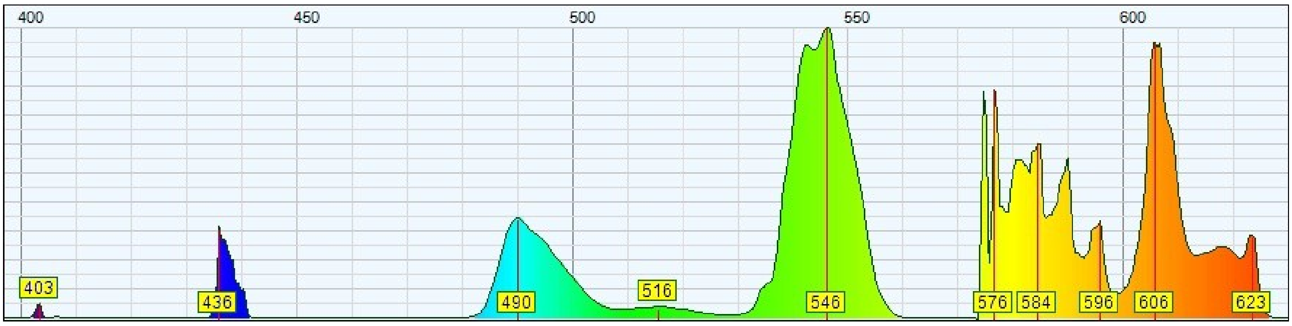
The lines at 436 and 546 nm are accurate. The position of the other rows is not stable and can change from one lamp to another.



Theremino Spectrometer that displays the spectrum of a fluorescent lamp

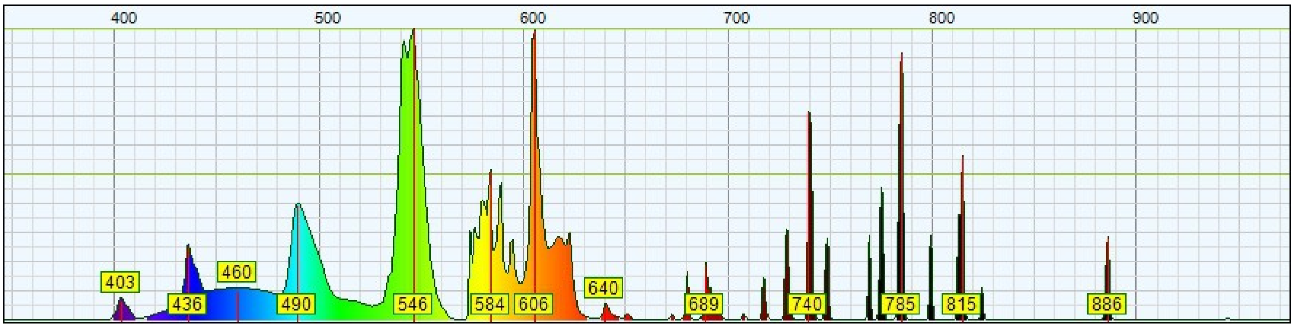
Other fluorescent lamps spectrums

This image shows the resolution of the spectrometer. The two yellow lines 574 and 576 are perfectly separated. Normally spectrometers economic and "DIY" do not have this resolution.

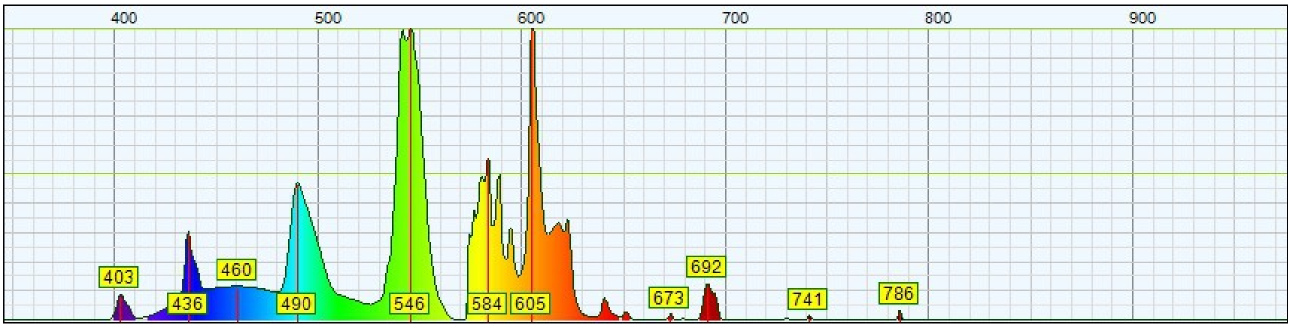


CFL lamp with the larger area of visible light.

In the two pictures below you can see that a fluorescent lamp just turned on, it emits a lot of lines in the infrared, beyond 700 nm. After heating, the energy emitted in the visible region increases and the lines in the infrared are reduced.



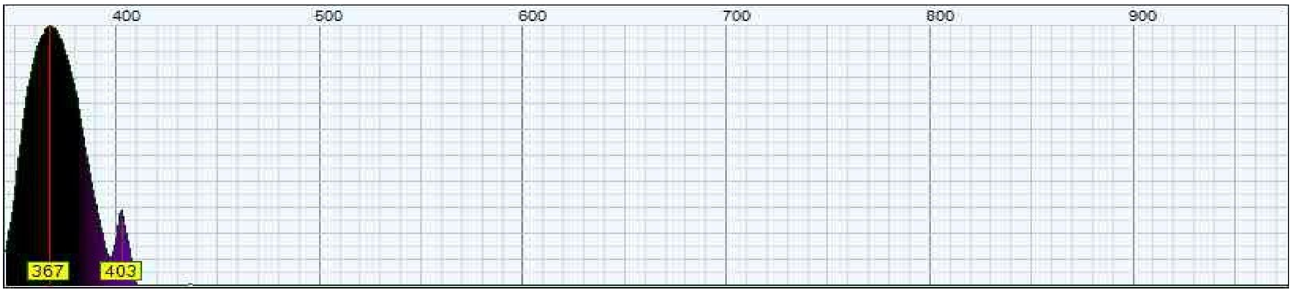
CFL lamp just turned on



CFL lamp after a few minutes of heating

Black light lamps (the "Wood" light)

These lamps contain a filter that eliminates almost all visible light, so as to bring out to the maximum the effects of fluorescence.



Spectrum of a fluorescent tube marked "BLB" (BL stands for "black light" and the B stands for "black")

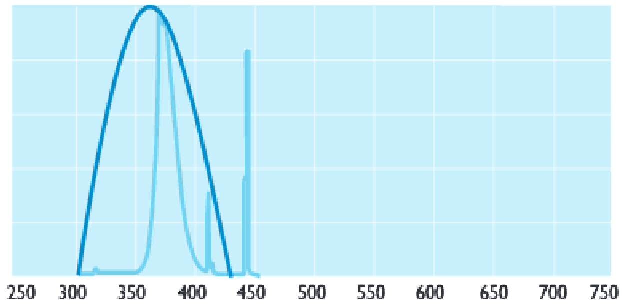
The spectrum shows that almost all the energy is emitted at 400 nm. The human eye can only see a faint light to dark purple color but objects strongly fluorescent light.

The wavelength of these lamps (about 360 nm) is suitable for the control of banknotes and to reveal traces of organic liquids, but is not suitable to control the olive oil.

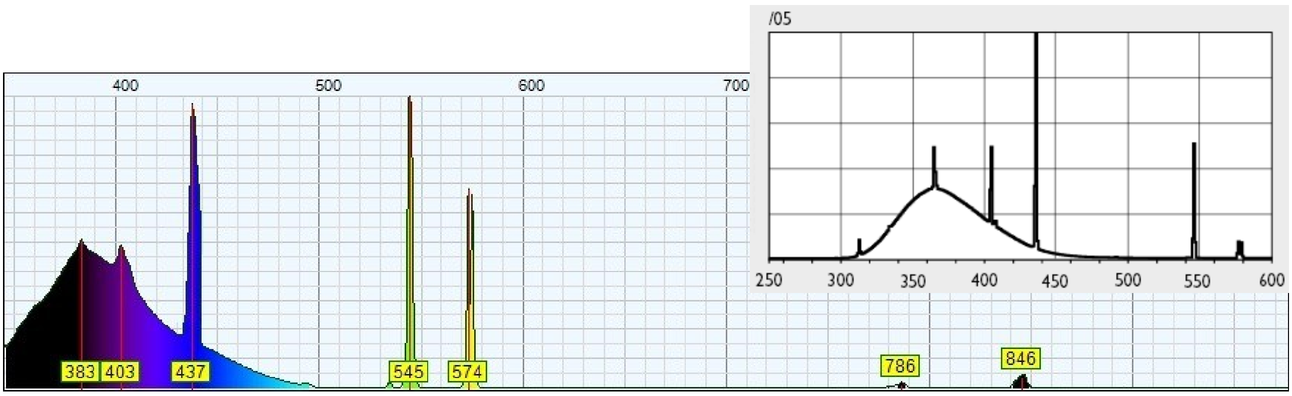
The chlorophyll fluorescence of olive oil is obtained with the LEDs and ultraviolet violet laser (wavelength around 405 nm).

Light Bulbs "Actinic"

These lamps are used to attract insects. They are similar to lamps in black light (black light), but not having a dark filter, also emit much visible light. The actinic Sylvania lamps are labeled "BL350" or "BL368" (the number after the BL indicates the nanometer peak energy), Philips those marked "05".



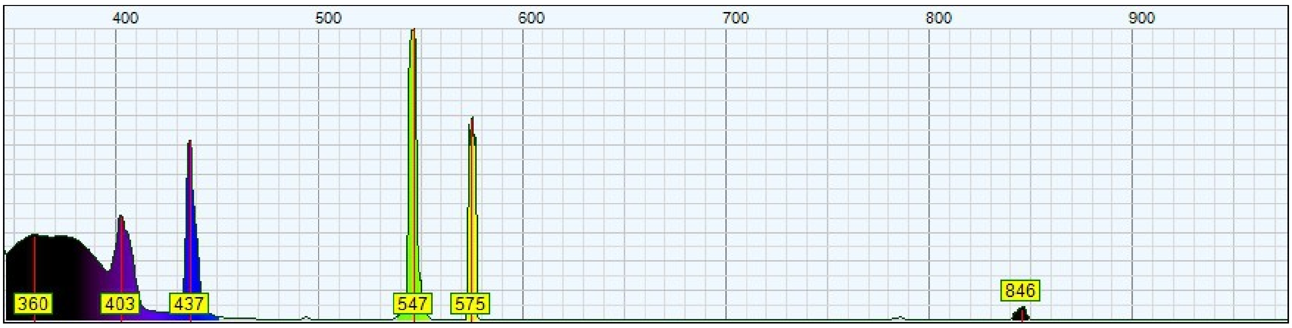
In dark blue the sensitivity of the eye of the fly, and in light-blue the light produced by a "actinic" lamp.



Spectrum of a Philips 6W/05 actinic lamp. Note the great similarity with the characteristics published by Philips (small spectrum at the top-right)

Tanning lamps

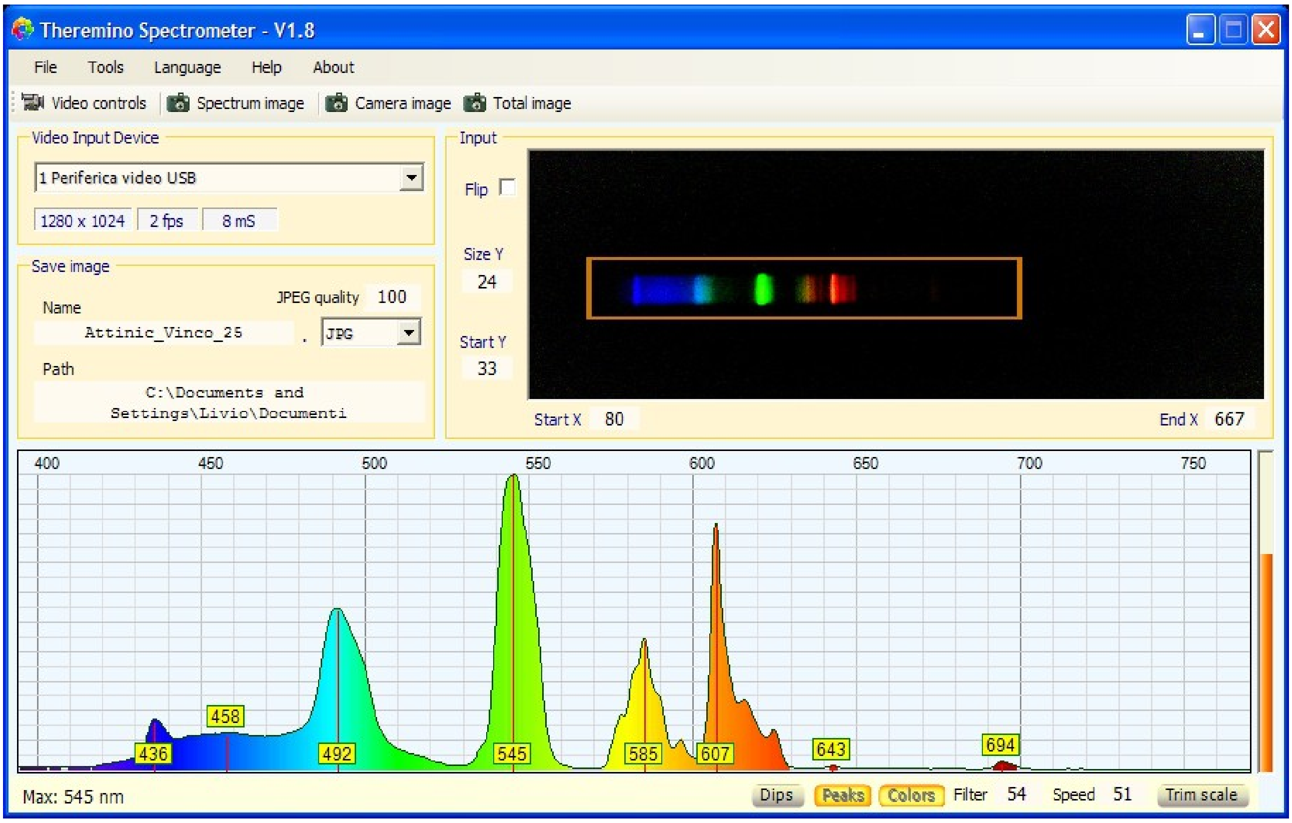
They have a spectrum very similar to actinic lamps, but the emission peak is lower (around 350-360nm).



Spectrum of a Philips 15W CLEO tube.

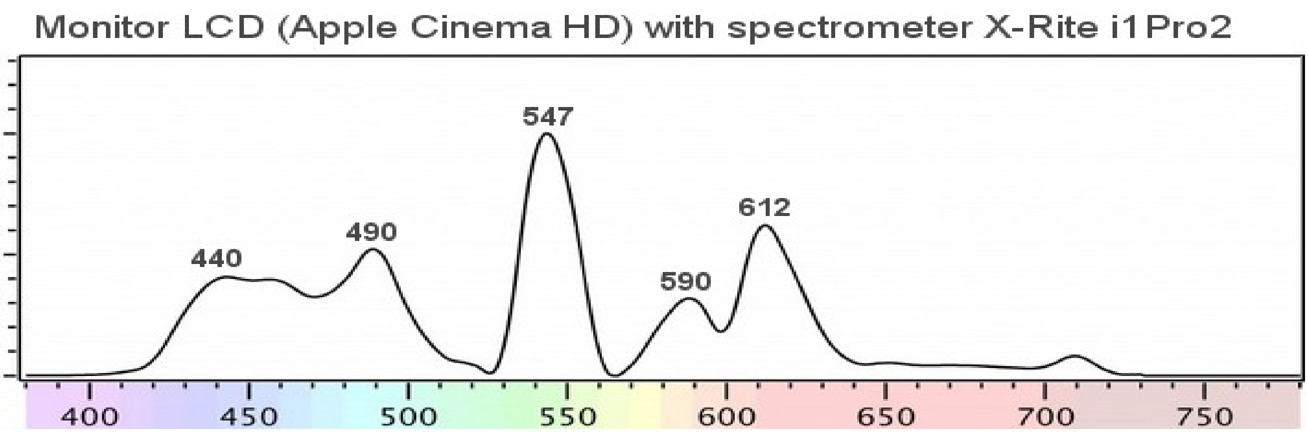
The colors of the LCD monitor pixels

Here we see an interesting comparison with a commercial spectrometer (X-Rite i1 Pro2). The graphics are quite similar, but the resolution of Theremino Spectrometer is better.



How Theremino Spectrometer see the white of the monitor Samsung SyncMaster 913

To measure the LCD monitor must be set to a white area on the screen, raise much brightness and contrast, remove the filter diffuser by the spectrometer and adjust the exposure for maximum sensitivity.

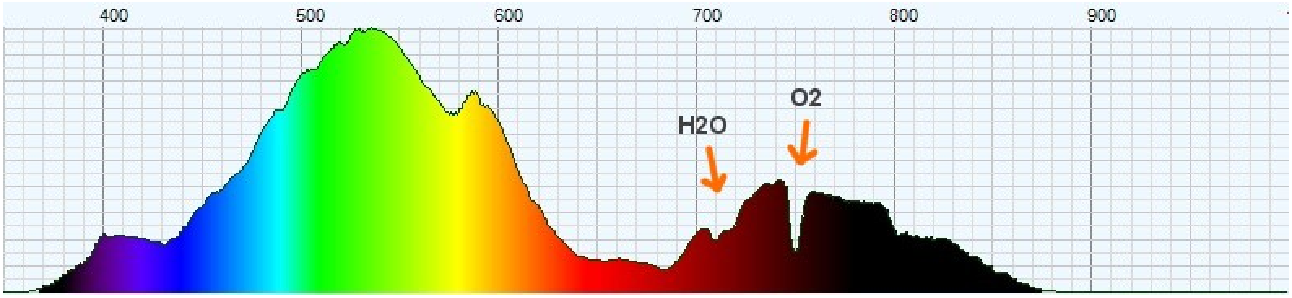


A similar graph produced by a spectrometer commercial that costs more than $ 1,000

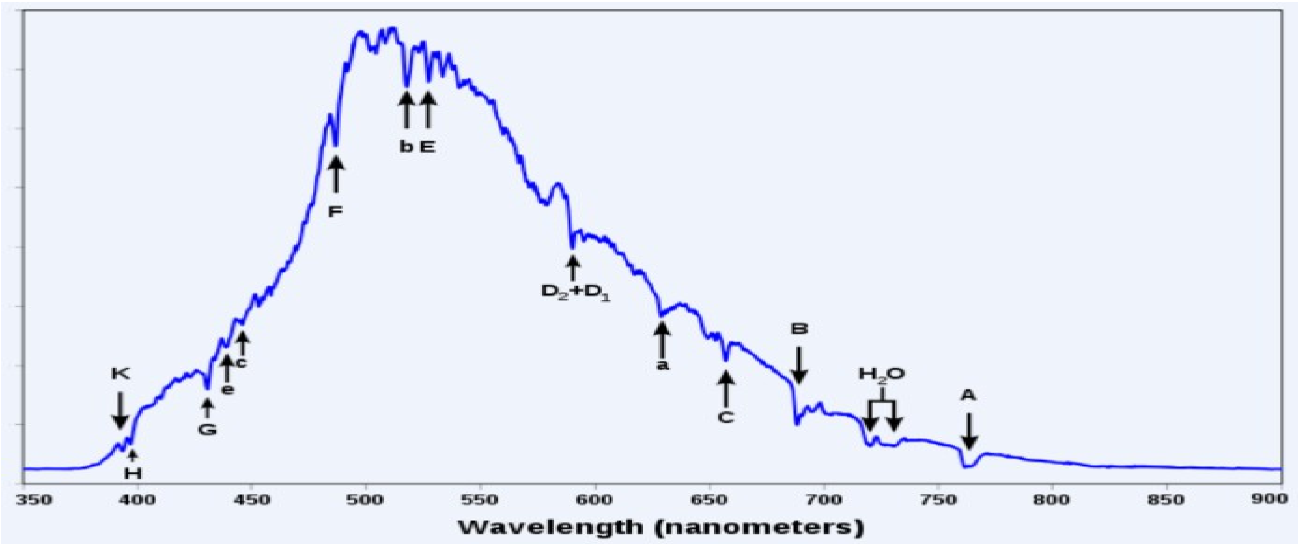
The high cost of X-Rite is partly justified by the fact that it also provides information on the "quantity" of light, while Theremino Spectrometer can not do it (webcams are not enough linear to be able to measure the amount of light they receive).

Spectrum of sunlight

The appearance of this spectrum varies depending on time of day, the area of the sky that is measured and the height above sea level. The atmosphere strongly absorbs some wavelengths and the ratio between the ultraviolet, visible and infrared light can vary greatly.



The following image shows the absorption lines (Fraunhofer lines), produced by substances present in the atmosphere.

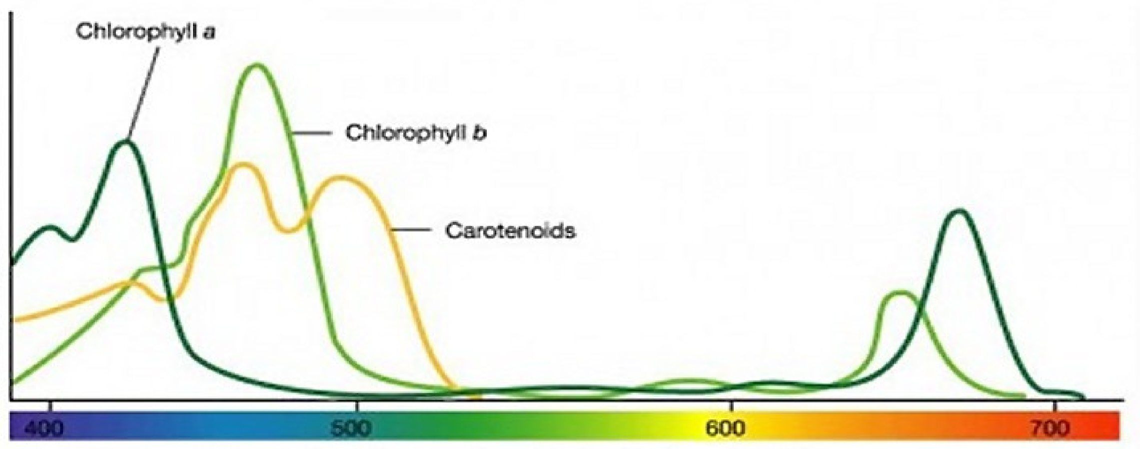


Designation	Element	Wavelength (nm)
y	O_2	898,765
Z	O_2	822,696
A	O_2	759,370
B	O_2	686,719
C	Hα	656,281
to	O_2	627,661
D_1	Na	589,592
D_2	Na	588,995
D_3 or d	He	587.5618
and	Hg	546,073
E_2	Fe	527,039
b_1	Mg	518,362
b_2	Mg	517,270
b_3	Fe	516,891
b_4	Mg	516,733

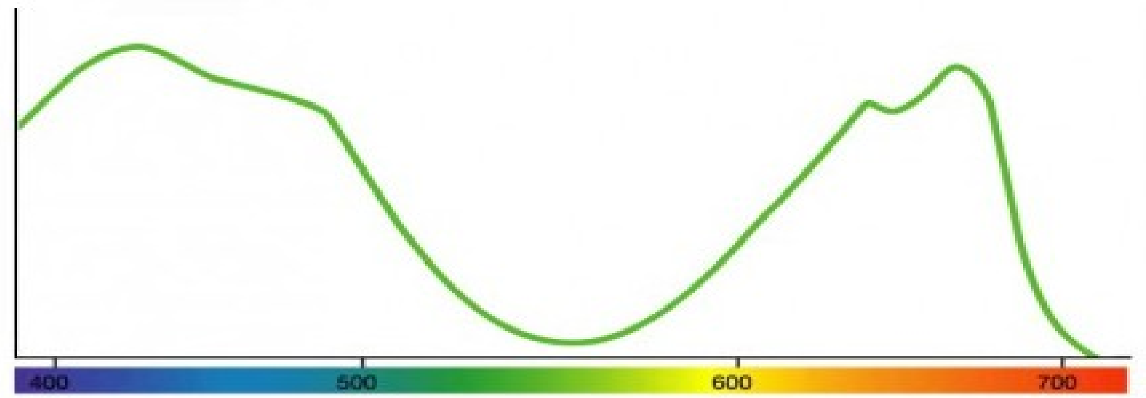
Designation	Element	Wavelength (nm)
c	Fe	495,761
F	Hβ	486,134
d	Fe	466,814
and	Fe	438,355
G '	Hγ	434,047
G	Fe	430,790
G	Ca	430,774
h	Hδ	410,175
H	Ca^+	396,847
K	Ca^+	393,368
L	Fe	382,044
N	Fe	358,121
P	You$^+$	336,112
T	Fe	302,108
t	Ni	299,444

Wavelengths absorbed by vegetation

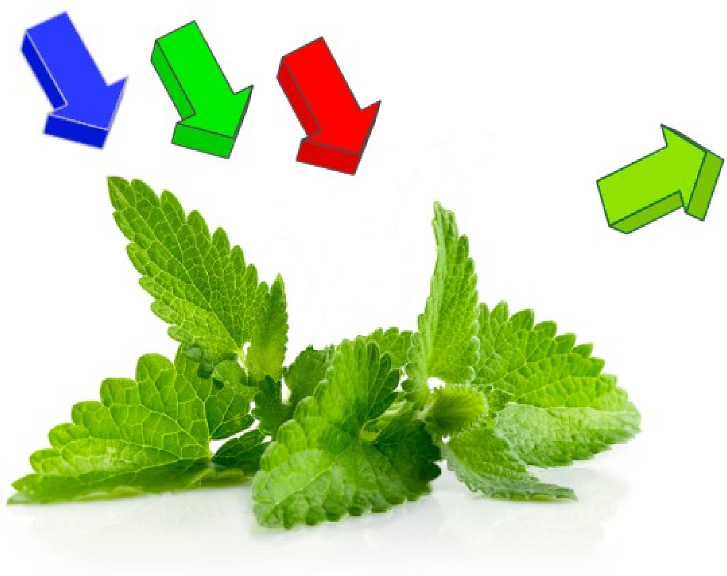
The vegetation preferably absorbs the wavelengths useful for producing energy (by means of photosynthesis of chlorophyll).



Wavelengths are absorbed more readily by vegetation



Wavelengths that provide more energy for photosynthesis



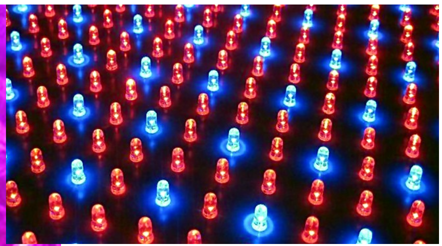
The plants obtain energy from light red and blue, but reflect green light.

The components of light green and green-yellow, the leaves would heat unnecessarily without providing a lot of energy.

This is why plants are green.

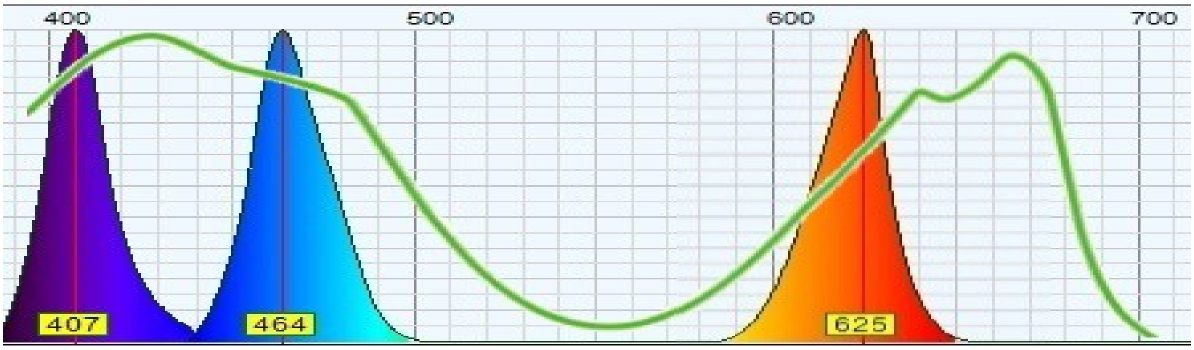
Lamps for plant growing

To grow plants efficiently, without wasting energy in the green area, blue and red LEDS are used.



Typical characteristics:
- Blue LEDs from 455 to 465 nm
- Red LEDs from 620 to 660 nm
- Blue-red proportion 3:1 to 7:2
- Output of the individual led to 60 mW to a few Watt

A lamp for growing plants



Output of LED ultraviolet, blue, and red superimposed with the photosynthesis efficiency curve

From this spectrum we note that the usual ultraviolet and blue LEDs have a good efficiency for photosynthesis (over 80%), but that the normal red LED (625 nm) have only 50% efficiency. For the cultivation are preferable red LEDs with a greater wavelength (About 660 nm).

The lower efficiency of the red LEDs and other considerations on the chemistry of plants, lead to the fact that the lamps have about three red LEDs for each blue LED. The red affects the flowering and yield, the blue affects the distance between the nodes of the stem, and the rapidity of growth.