SCIENTIFIC CASE:

Stellar composition

Team members

Writer: ____

Equipment manager: ____________________________________

Reader: ____

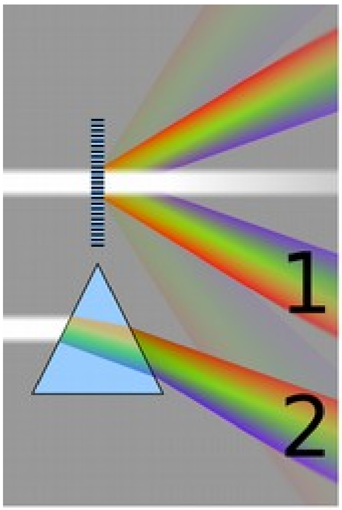
Spokesperson: _______________________________________

Context

In 1671, Isaac Newton (1643-1727) described how, when a ray of sunlight goes through a crystal prism with a particular angle, it splits showing different colours.

Left: Newton's Experimentum Crucis (Grusche 2015) -fragment | Right: Prism splitting white light into spectral colours. Source: Wikimedia.org .

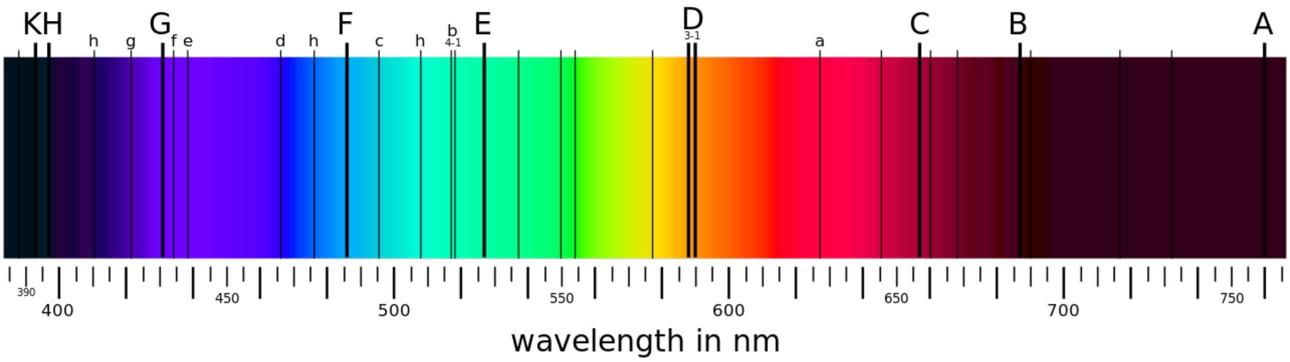
Newton also explained that light coming from stars other than the Sun would also be separated by a prism in a similar fashion.



More than a century later, in the first years of the 19th Century, Joseph von Fraunhofer (1787-1826) took a big step – he replaced the prism by a more effective optical component: a diffraction grating. This grating had de ability to separate or diffract light into several, more distinguishable rays.

Comparison between a prism and a diffraction grating. Source: Wikimedia.org

That way, Fraunhofer could split sunlight with a better resolution and, when he did, he found out something extraordinary: **light wasn't continuous, but had black lines** along the spectrum.

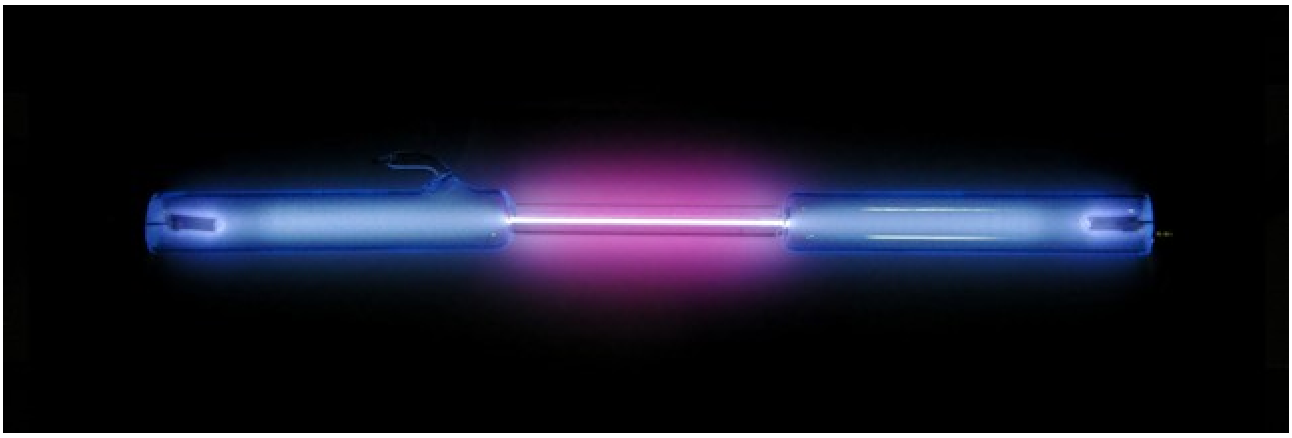


Fraunhofer's lines. Source: Wikimedia.org

So, what do these black lines mean?

The Sun emits light due to its high temperature but, on its way from the inside to space, elements in the star absorb part of that light. That is, **each one of the Sun's chemical elements always absorbs the same colours**. In other words: **if we could know which lines are absorbed by which chemical elements, we could know what our star is made of!**

Now imagine we could introduce a specific gas in a glass tube (for instance, hydrogen). If we apply an electrical current to it, its electrons will be excited and they will emit light.

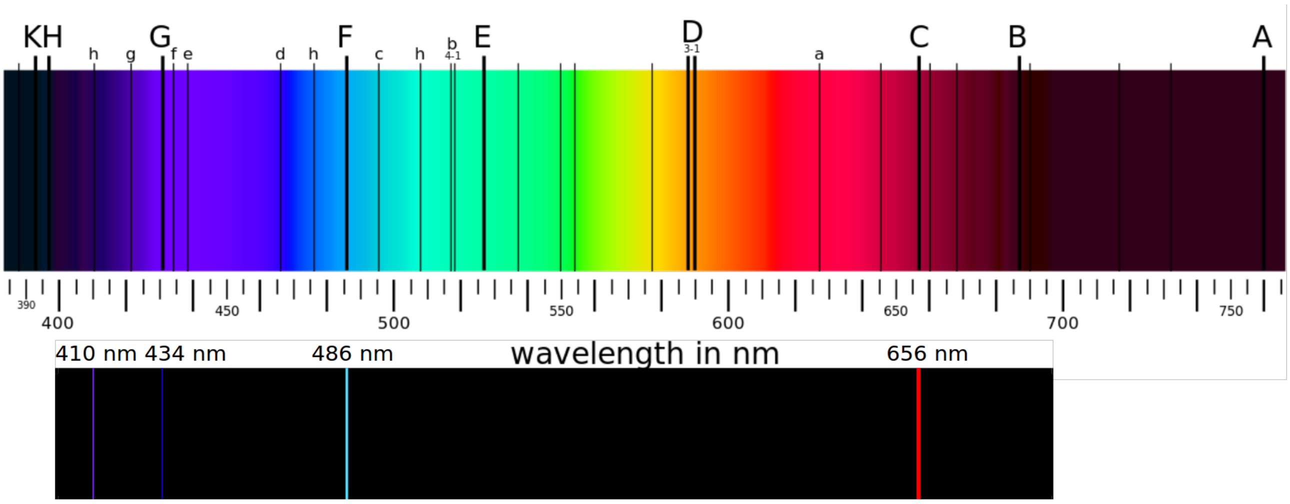


Hydrogen lamp. Source: Wikimedia.org

If, as Newton and Fraunhofer did, we then split up hydrogen light with a prism or a diffraction grating, this would be what we'd see:

Emission lines from Hydrogen's Balmer series: Wikimedia.org

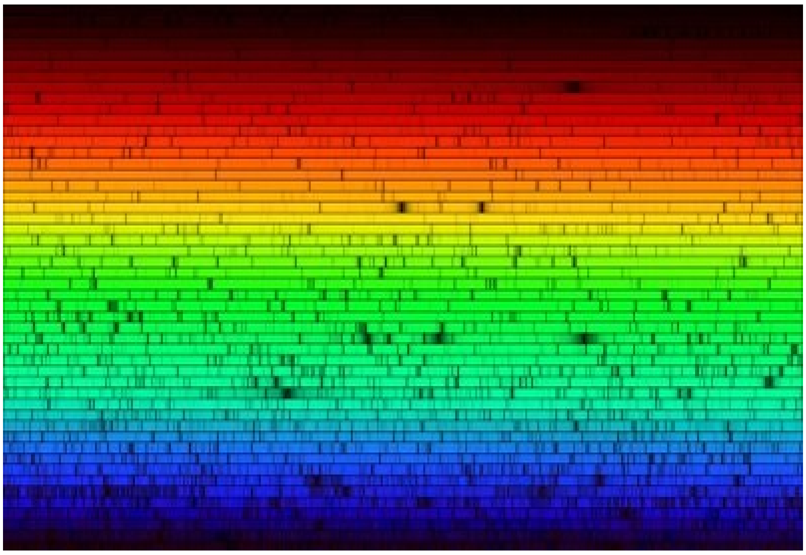
Now let's compare the Sun's spectrum with the lines emitted by hydrogen.



Cecilia Payne (1900-1979) discovered that the lines that are emitted by hydrogen are a match for some of the Sun's absorption lines; thus, **there is hydrogen in the Sun!** In other words, hydrogen in the Sun absorbs light in the same way hydrogen emits light when we excite its electrons.

With this finding, we just have to know the emission lines for other chemical elements in order to know what the Sun is made of.

In the same way, we can also find other stars' composition by studying their spectrum, just as we did with the Sun.



Complete visible range solar spectrum (N.A.Sharp, NOAO/NSO/Kitt Peak FTS/AURA/NSF). Source: esa.int

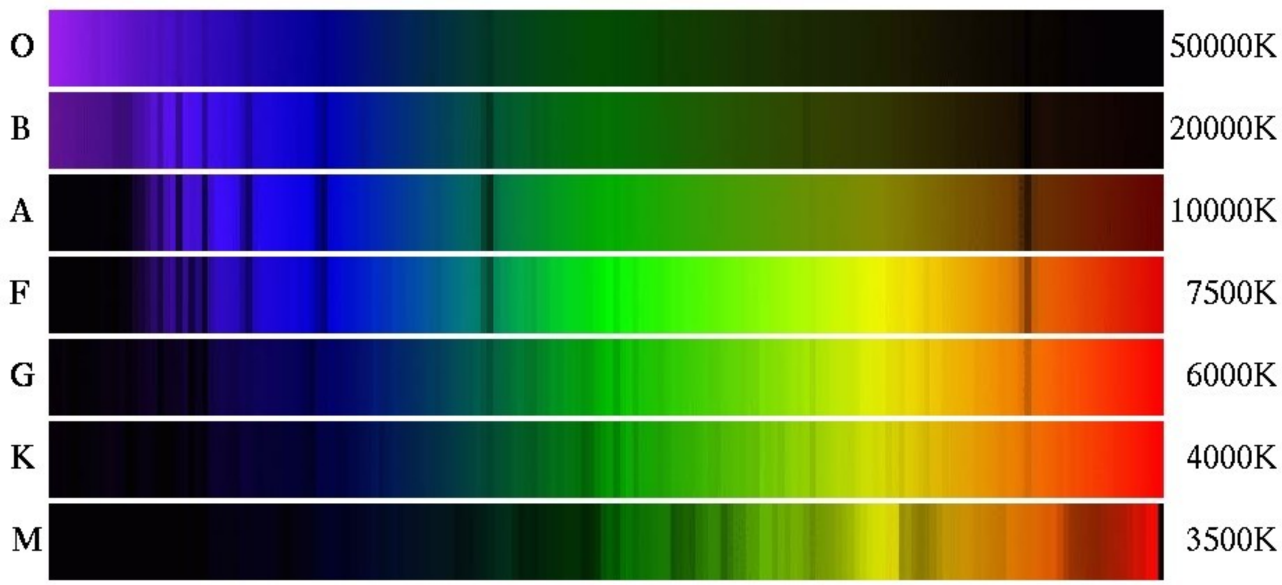
More educational resources:

CESAR: http://www.cosmos.esa.int/web/cesar
ESA education: http://sci.esa.int/education/
Stellar distances: http://sci.esa.int/education/35616-stellar-distances/?fbodylongid=1667

Scientific case: Which elements are inside the Sun and other stars?

The aim of this experience is **getting to know the main elements that are inside the Sun and other stars.**

The stellar composition is related to their temperature, and we can classify them according to this. For a start, we can differentiate 7 main stellar classes (O, B, A, F, G, K and M). Specifically, the Sun is “type G” star. The classification can be further refined, and more classes can be added, but we will limit ourselves to this representative sample.



Credit: Armagh Observatory

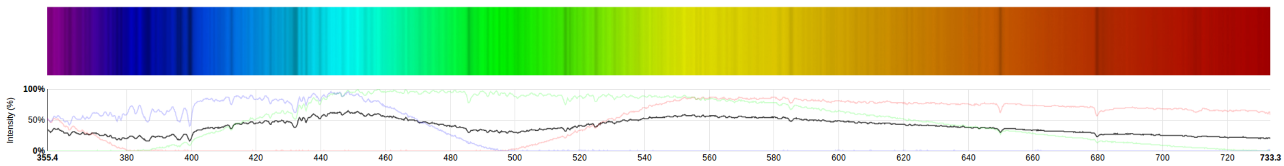
Research equipment

You have access to the following:

- Pencils, paper, rubber, ruler.
- Spectra from several stars.
- Emission lines from different gases.

Procedure

1. Each team chooses a type of star to analyze (for instance, “Star type G”). Inside the research equipment you will see the spectrum of a star and a graphic with peaks that mark the star's absorption lines.



Star type G

The X axis corresponds to the wavelength of each color, expressed in nanometers (nm). The Y axis refers to the intensity of the light, scaled to a pecentage between the brightest and faintest points.

2. To find out the composition of the star, you have to compare the emision lines from different gases to the absorption lines of the star.

Compare the graphics of your star with the different chemical elements that appear in the research equipment[1].

You can see more spectra in:
http://chemistry.bd.psu.edu/jircitano/periodic4.html

3. Share what you have found with your classmates and compare your compositions.

1 You can do this by only comparting the lines that appear more clearly. Consider a margin for error of about 10 nm.

Results

Type of star
Composition
If you are not sure of the presence of a specific chemical element, write it down and explain why.

Questions and conclusions

What difficulties have you found? How can this research be improved?

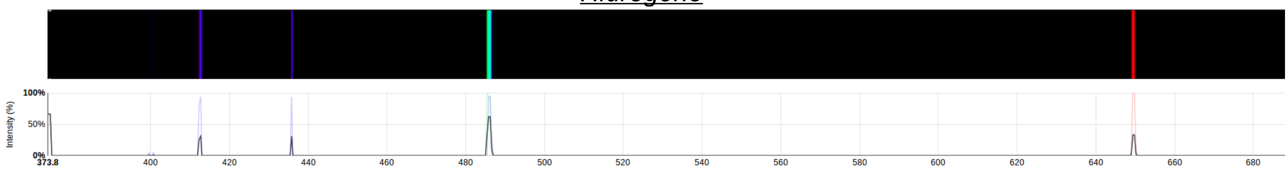
Look closely at the periodic table of elements in the attached document. Not every element appear in all the stars. Why do you think that is?

It has been observed that stars' composition is similar to other stars with the same temperature. Why could that be?

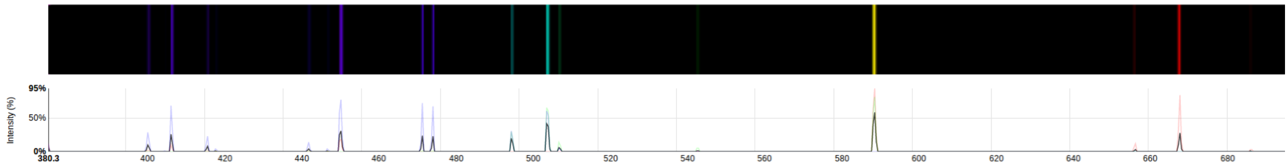
Research equipment

Emission lines of different gases

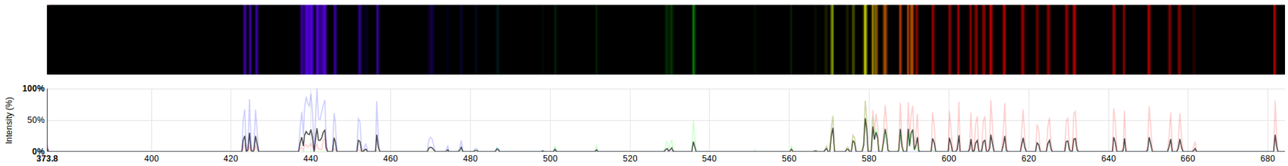
Hidrógeno



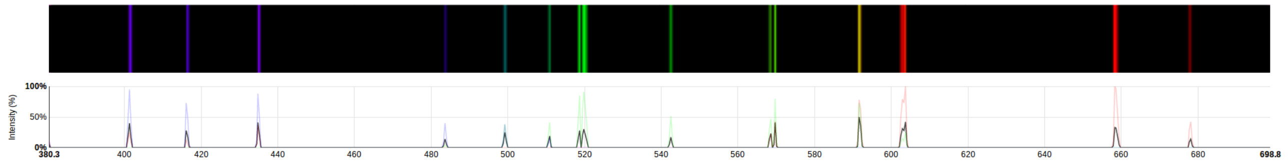
Helio



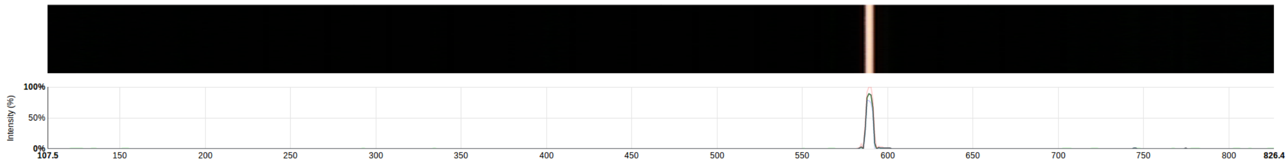
Neón



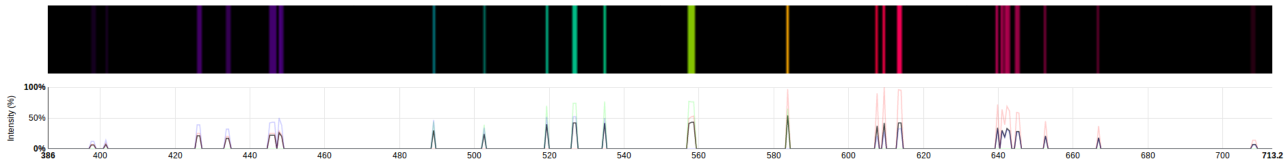
Carbón



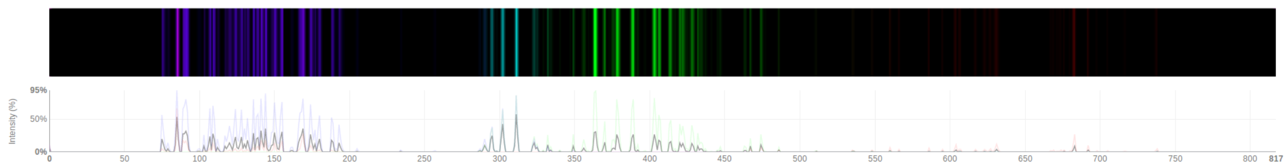
Sodio



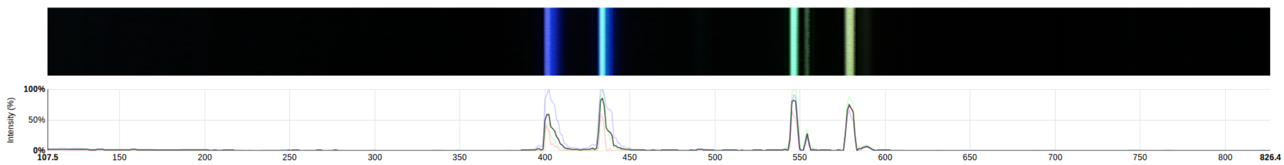
Calcio



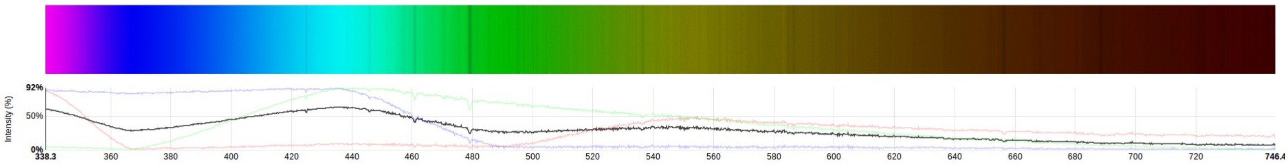
Hierro



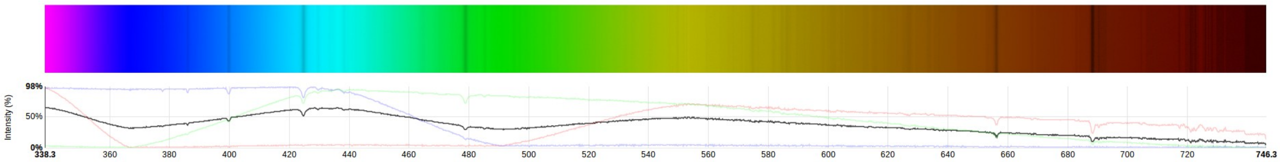
Mercurio



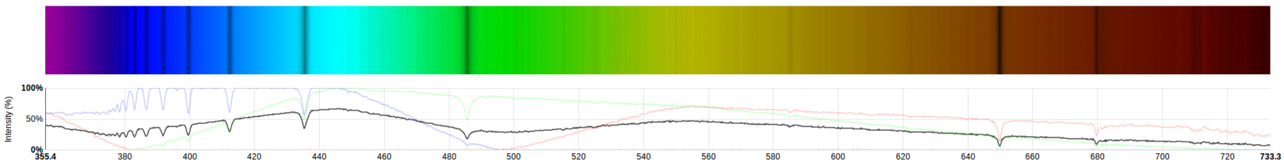
Absorption lines of different types of stars



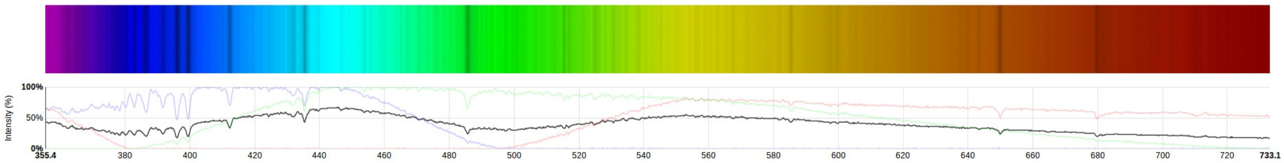
Star type O



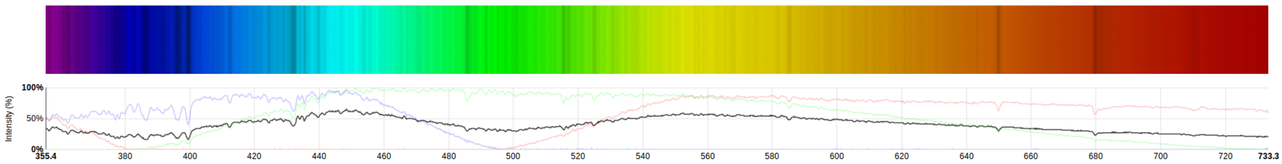
Star type B



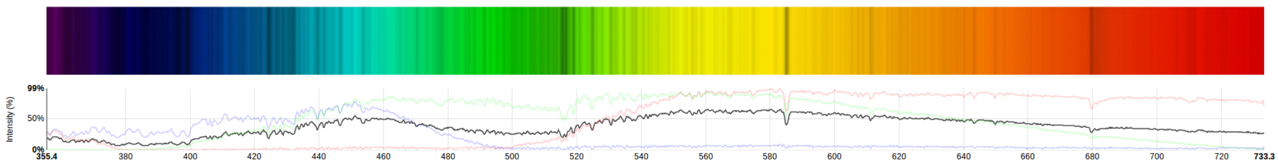
Star type A



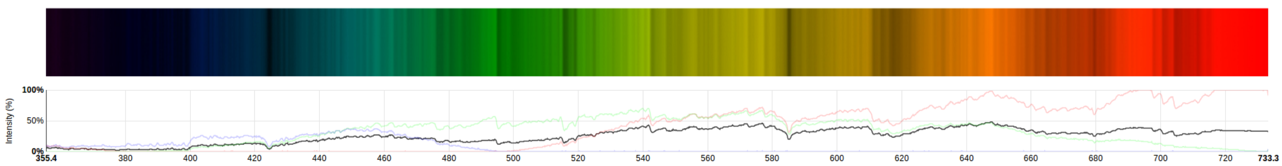
Star type F



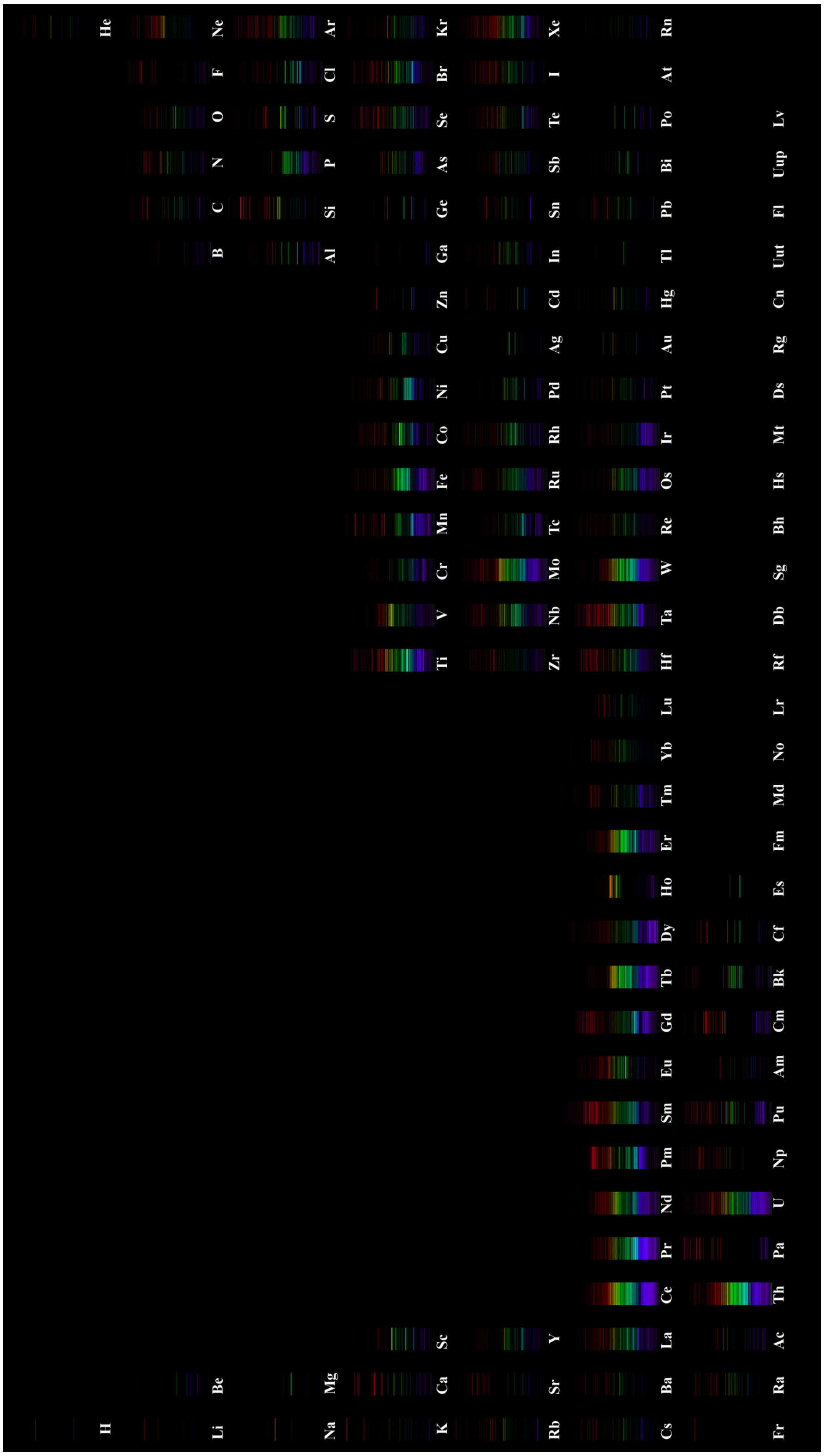
Star type G



Star type K



Star type M



Periodic table with the spectra of the elements (cortesy of umop.net)