AGA0414
Spectroscopy

Prof. Alessandro Ederoclite

White is not a colour

If you let "white light" pass through a prism made of glass, you split it in the colours of the rainbow.
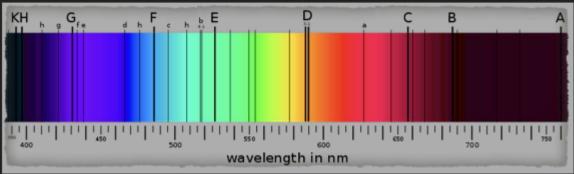
Discovered by Sir. Isaac Newton.

[Trad.] White light is a superposition of light at different wavelengths, which are separated by a prism thanks to Snell's law
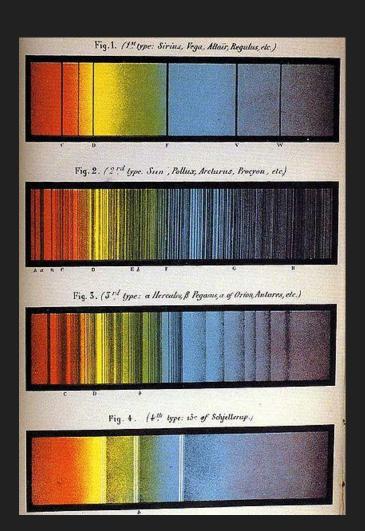
Fraunhofer: the Sun has "dark lines"

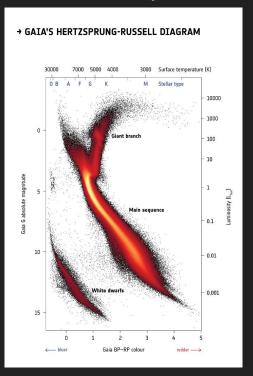1787 - 1826

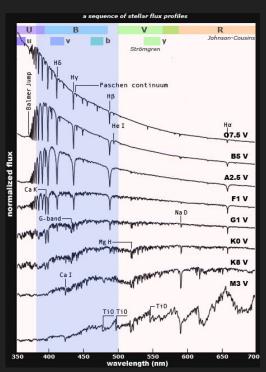# Secchi: stellar spectroscopy

1818 - 1878

First attempt to classify stars.

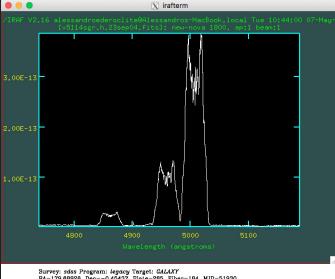# (Main Sequence) Stars of different temperatures
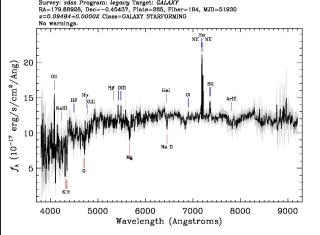
From qualitative to quantitative

We use quantum physics to derive densities
and temperatures.

You can tell temperatures with colours
(e.g. the B-V colour was designed for
this), but they are far less precise.

We use relativity/Doppler to derive velocities
(e.g..planet finding or distant galaxies)

This is how we discovered that stars are made of
(mostly) hydrogen. Btw, who discovered it?

Cecilia Payne-Gaposhkin

Do not undertake a scientific career in quest of fame or money. There are easier and better ways to reach them. Undertake it only if nothing else will satisfy you; for nothing else is probably what you will receive. Your reward will be the widening of the horizon as you climb. And if you achieve that reward you will ask no other.

The reward of the young scientist is the emotional thrill of being the first person in the history of the world to see something or to understand something. Nothing can compare with that experience... The reward of the old scientist is the sense of having seen a vague sketch grow into a masterly landscape."

https://www.epigenesys.eu/en/science-and-society/women-in-science/808-cecilia-payne-gaposchkin

How to build a spectrograph

The heart of the spectrograph is the "dispersing element".

Normally you have:

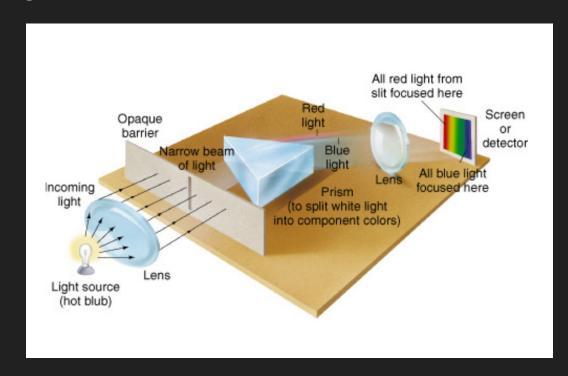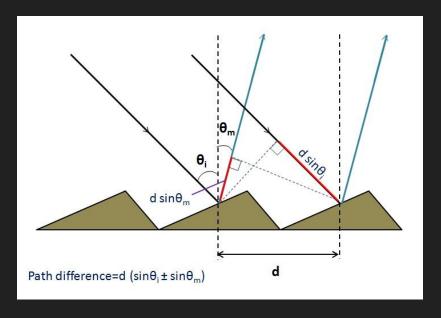- A slit (to select an object)
- A collimator
- A camera

Figure stolen from R.Costa

The reflecting grating

The maximum happens when

$d \sin \theta_m / \lambda = |m|$

$m = -1$ $m = 0$ $m = +1$

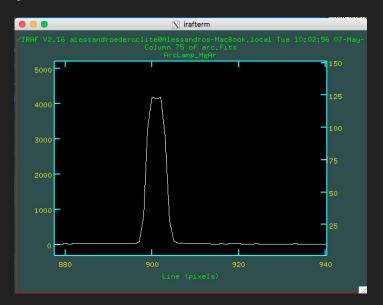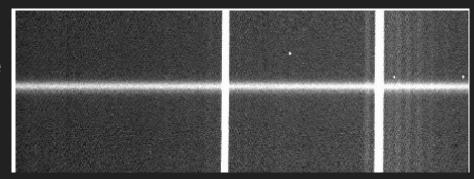Path difference=d $(\sin\theta_i \pm \sin\theta_m)$

https://en.wikipedia.org/wiki/Diffraction_grating

Definition: dispersion and resolution

On a CCD, the spectrum is "dispersed": the dispersion is how many Angstrom are in a pixel.

The "resolution" R = λ / δλ (where δλ ~ 2 dispersion) is the smallest separation between two lines that I am able to measure (reminds of the Airy disc).

Examples

Dispersion: 3Å/pixels -> δλ ~ 6Å -> R (@6000Å) = 1000

If CCD = 2000pixels in the dispersion direction and the first pixel has 4000Å, the maximum wavelength will be 4000Å + 2000 * 3 Å = 10,000Å

Dispersion: 0.1Å/pixels -> δλ ~ 0.2Å -> R (@6000Å) = 30,000

If CCD = 2000pixels in the dispersion direction and the first pixel has 4000Å, the maximum wavelength will be 4000Å + 2000 * 0.1 Å = 4,200Å
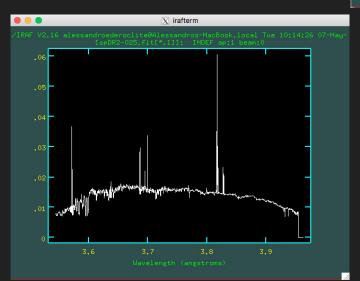
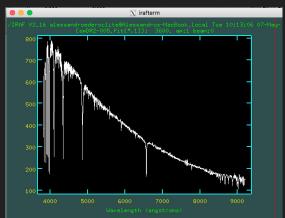The higher the resolution, the smaller the "spectral range"

Definitions: continuum and lines

Continuum
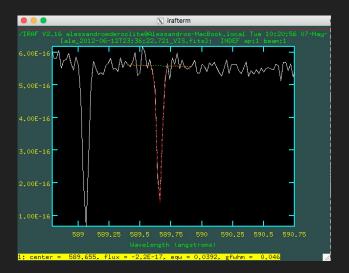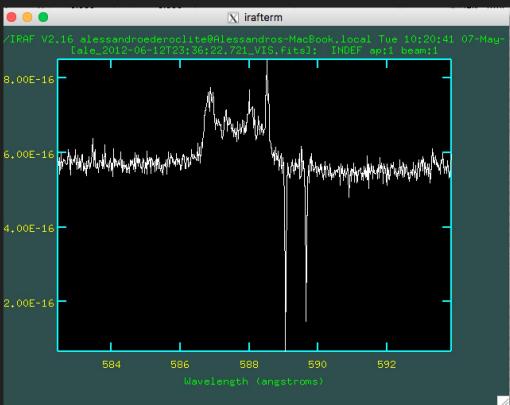
Lines:

- Emission
- Absorption

Definitions: continuum and lines

A line is defined by:

- Centroid
- FWHM

Prism, grating or "grism" => Resolution

Element	Resolution	"Definition"
Prism	<100	Low resolution
Grism	<2,000	Low resolution
Volume Phase Holographic G.	2,000 < R < 10,000	Low / Intermediate Resolution
Gratings	> 10,000	Intermediate / High resolution

See you on Thursday in the IT lab