Processing & Calibrating Spectra

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Advert

- Process spectra yourself
- Impress your friends and family with the scientific data you’ve produced!
- Print out at home and frame and put up on wall for all to see and admire!

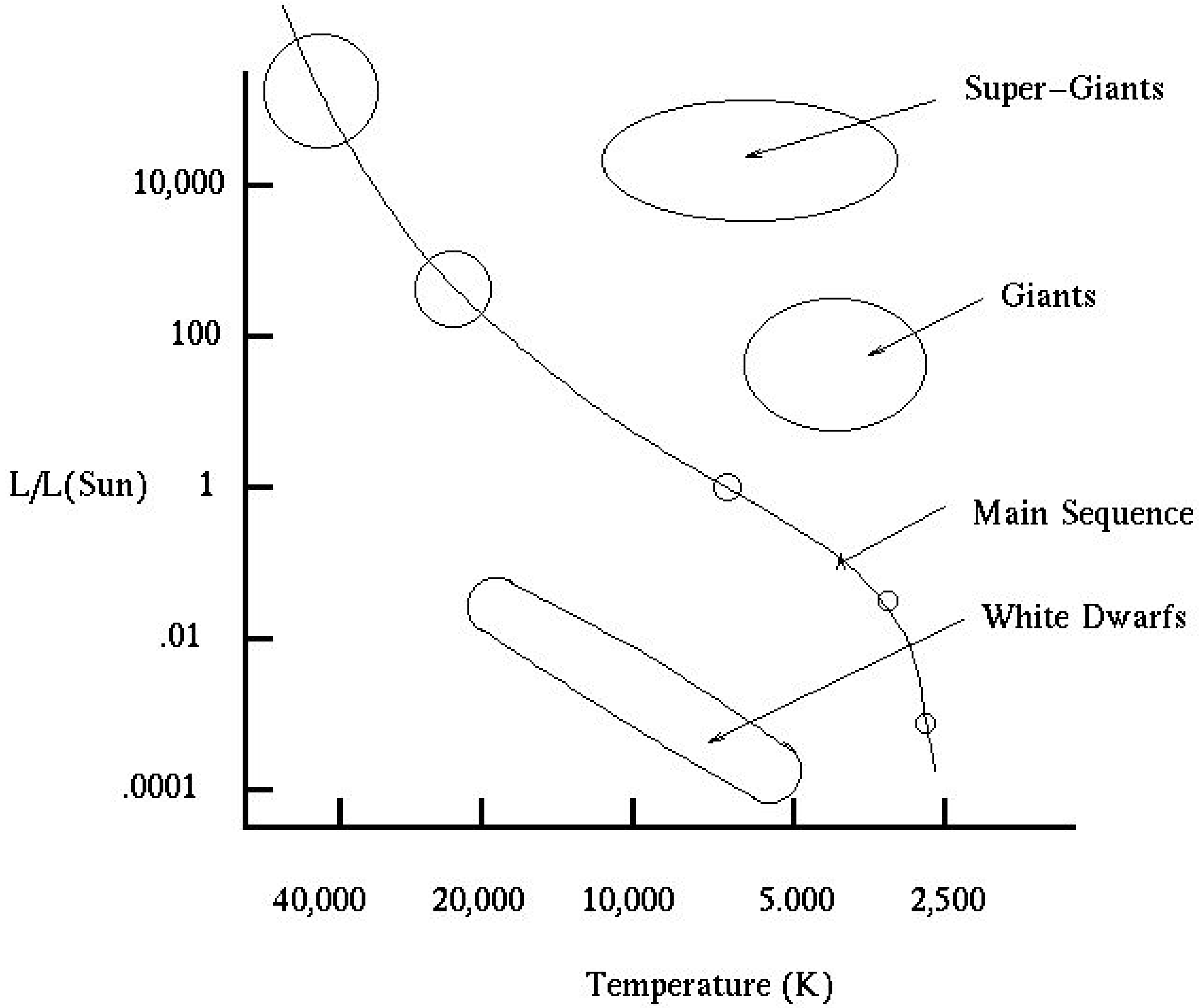
What audience needs to bring to session

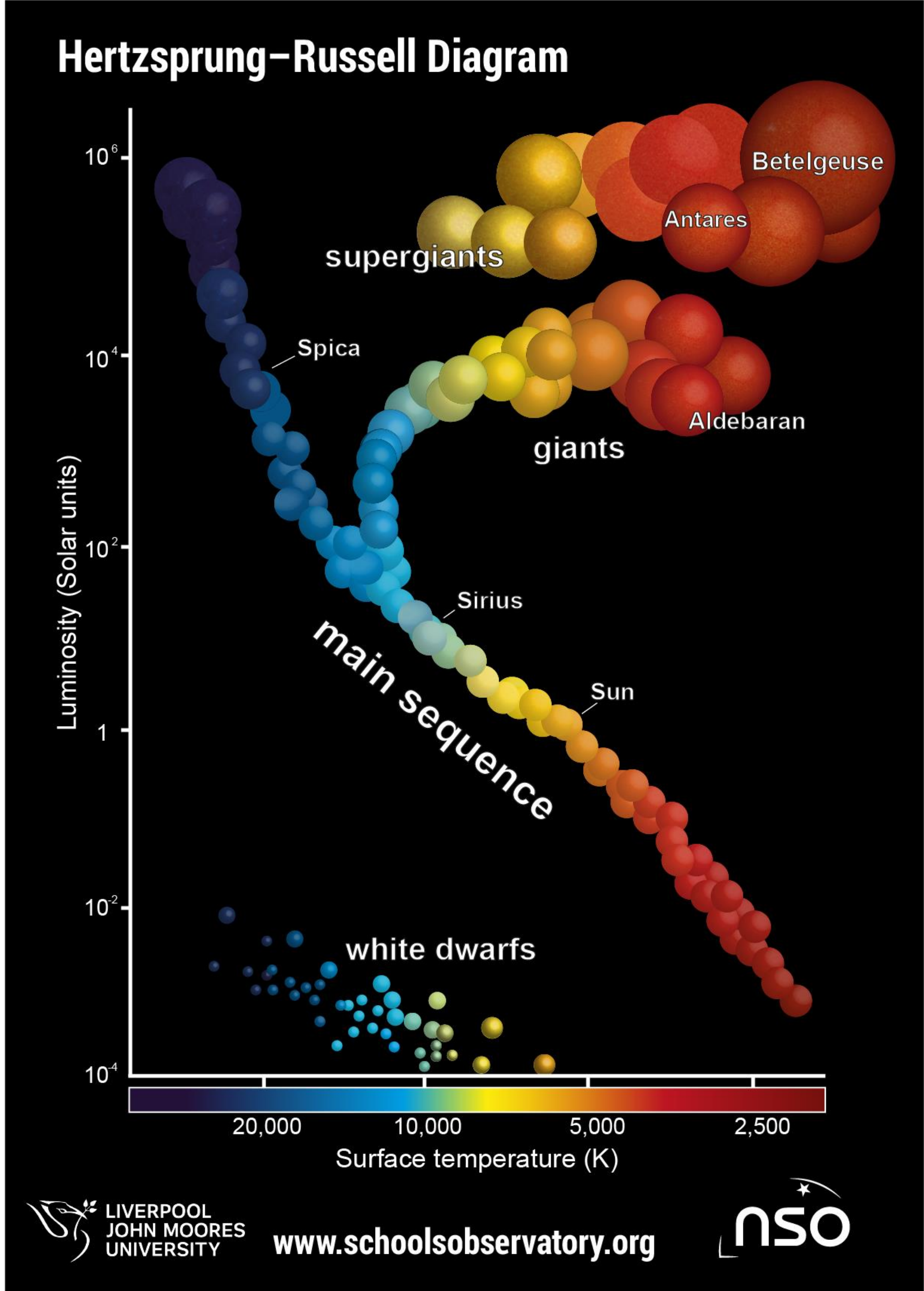
- Their laptops and chargers
- They need to download VSPEC and spectra onto their laptops in advance

Learning plan for session

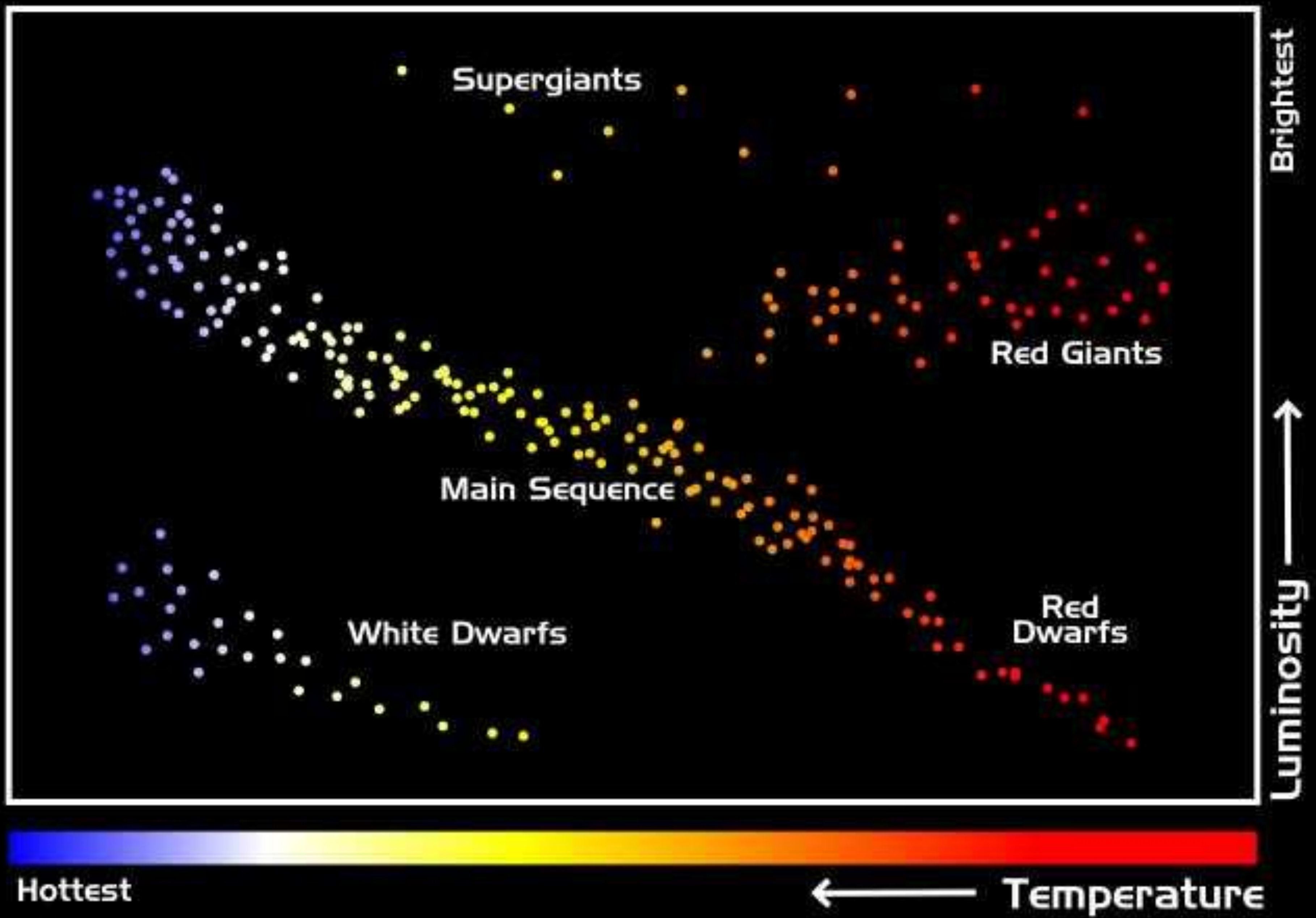
- Need to download VSPEC on my laptop and try all this out on that first.
- I need spectra including CFL spectra on my laptop.
- Ask people to download VSPEC and spectra I send which should include CFL spectra taken with same camera and telescope and spectrometer as other spectra. Both I and participants need to bring their laptops and chargers to session. I also need CFL and lamp.
- Start by describing what session is about - we are going to GP through process of processing data together and then I've got some spectra for them to try themselves.
- Show them VSPEC.
- Say as part of process we will need to calibrate the spectrum which means we compare it to known spectrum where we know the frequencies and we can then put this into the software. We are going to use CFL where frequencies on Wikipedia.
- Start by loading up CFL spectrum to VSPEC and go through calibration routine to get VSPEC to display wavelengths.
- Then load up whatever spectrum I am going to use as example. Correct orientation and other processes on VSPEC to get spectrum displayed. Then look at main lines and compare these to list lines.
- Describe what Balmer series is and show diagrams of electron transitions.
- Get audience to do it themselves on several examples

Hertzsprung Russell Diagram And Stellar Evolution

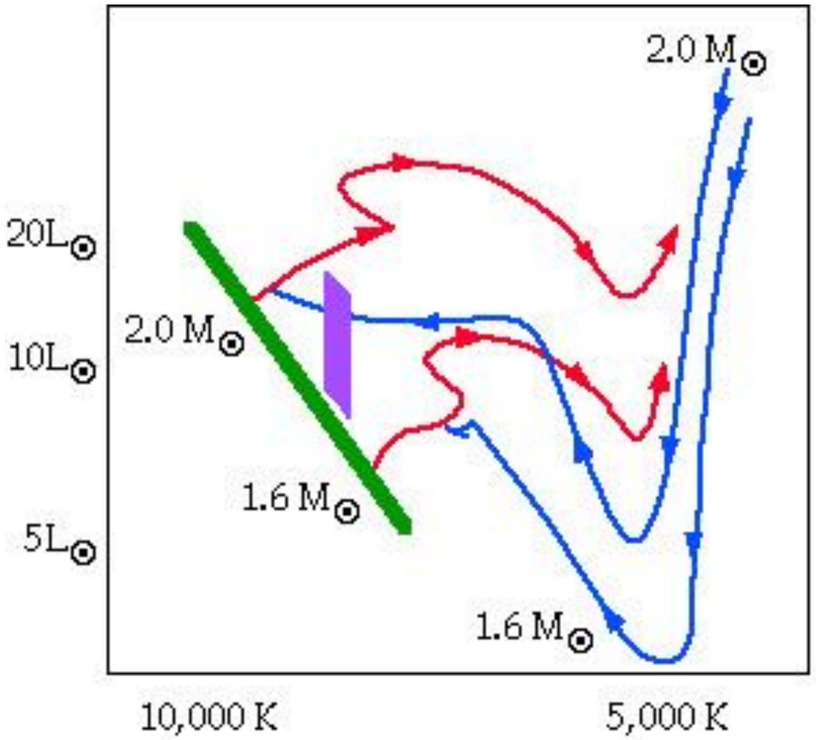




Hertzsprung-Russell Diagram



Examples of stellar evolution curves for stars of 1.6 and 2.0 solar masses.

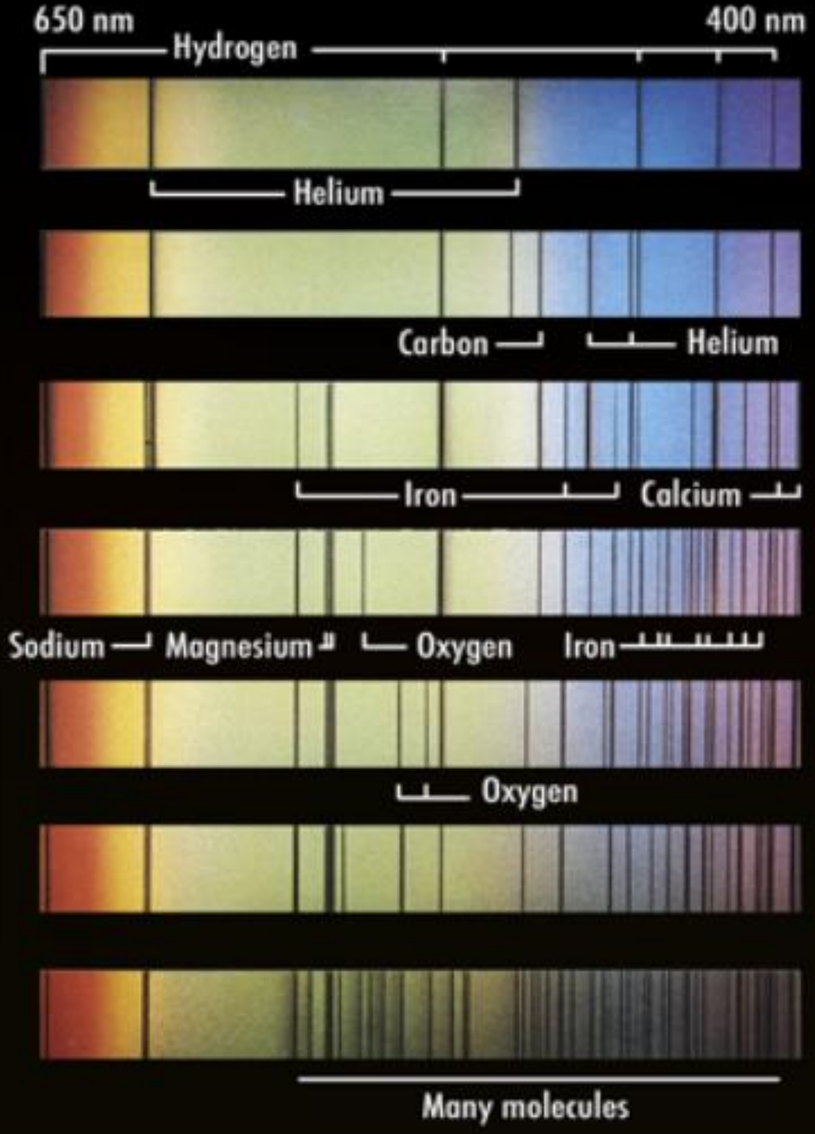


- **Blue curves** = track followed by the collapsing protostar = called *Hayashi Tracks*.
- **Green line** = main sequence, where the star spends most of its lifetime sitting around fusing hydrogen into helium.
- **Once star stops burning hydrogen in core** ➔ expands ➔ moves off main sequence ➔ towards upper right (the *giant* region).
- **More massive stars** sit hotter portion of main sequence, live shorter lives than the less massive stars, and become larger giants.
- **Less massive stars** sit cooler portion of main sequence, live much longer lives, and may never become giant stars at all.
- **Our sun** should remain similar to now on main sequence, for about 8,000,000,000 years.
- **Supermassive hot star**, =/> 20,000 C ➔ main sequence for =/< 1,000,000 years.
- **Cool red star**, =/< 3000 C ➔ main sequence for up to 100,000,000,000,000 years.

Harvard Stellar Classification

STELLAR CLASSIFICATION (MAIN-SEQUENCE)

SPECTRUM



CLASS	COLOR	TEMP. (C°)	HYDROGEN	SIZE(SOLAR R)	% OF ALL
O		>30,000	WEAK	>6.6	~0.00003%
B		9,700 - 30,000	MEDIUM	1.8 - 6.6	0.13%
A		7,200 - 9,700	STRONG	1.4 - 1.8	0.6%
F		5,700 - 7,200	MEDIUM	1.1 - 1.4	3%
G		4,900 - 5,700	WEAK	.9 - 1.1	7.6%
K		3,400 - 4,900	VERY WEAK	.7 - .9	12.1%
M		2,100 - 3,400	VERY WEAK	<.7	76.5%

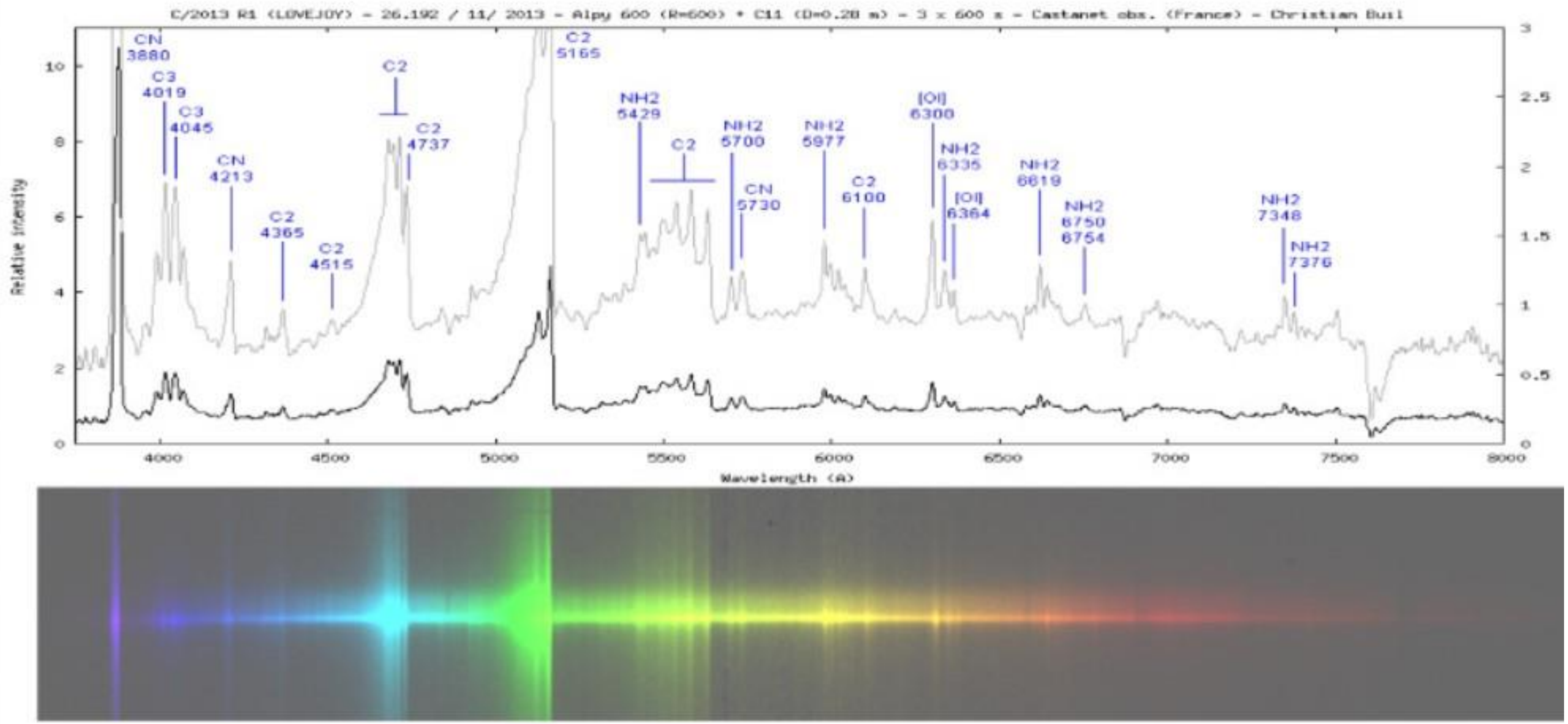
Order of stellar types from hot stars to cool is O, B, A, F, G, K, M.

Mnemonic:

"Oh, Be A Fine Girl [or Guy], Kiss Me".

Classification initially based on appearance & strength of certain spectral lines, but later understood to reflect stellar temperatures[3]*.*

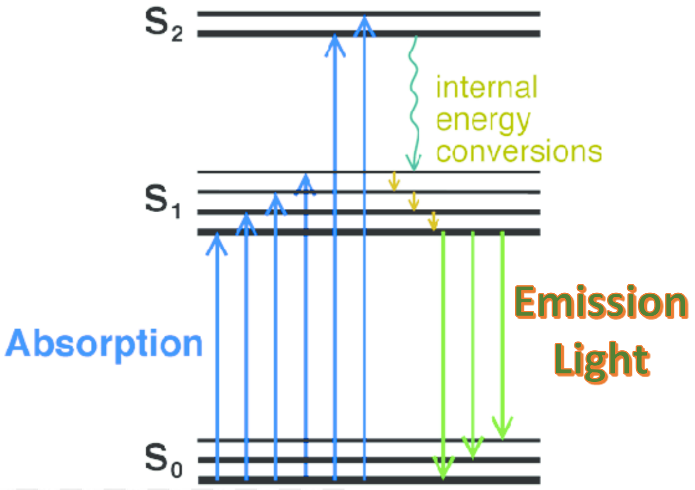
Spectroscopy Processing = Turning spectrum below into plot above so that it can be interpreted

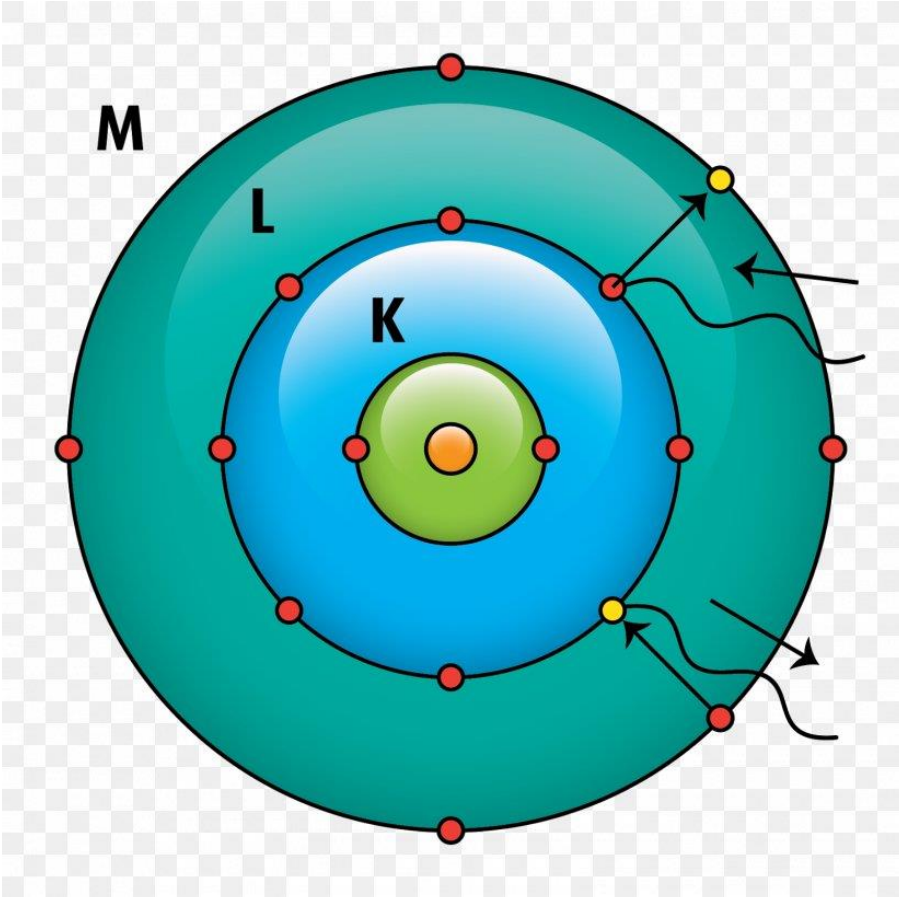


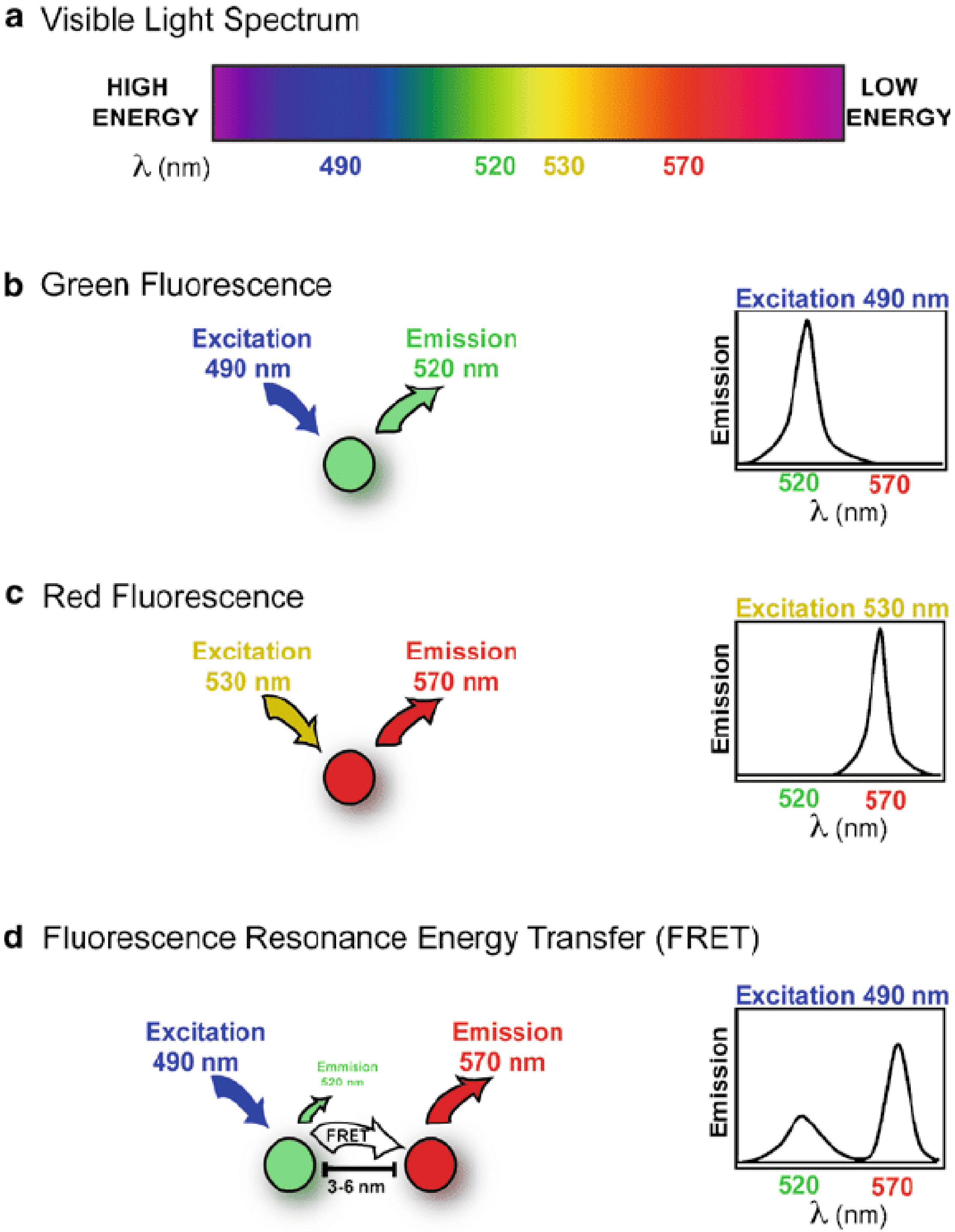
Peaks on the spectrum = main spectral lines of this spectrum

Each element/molecule has unique spectral signature which we can identify in spectra

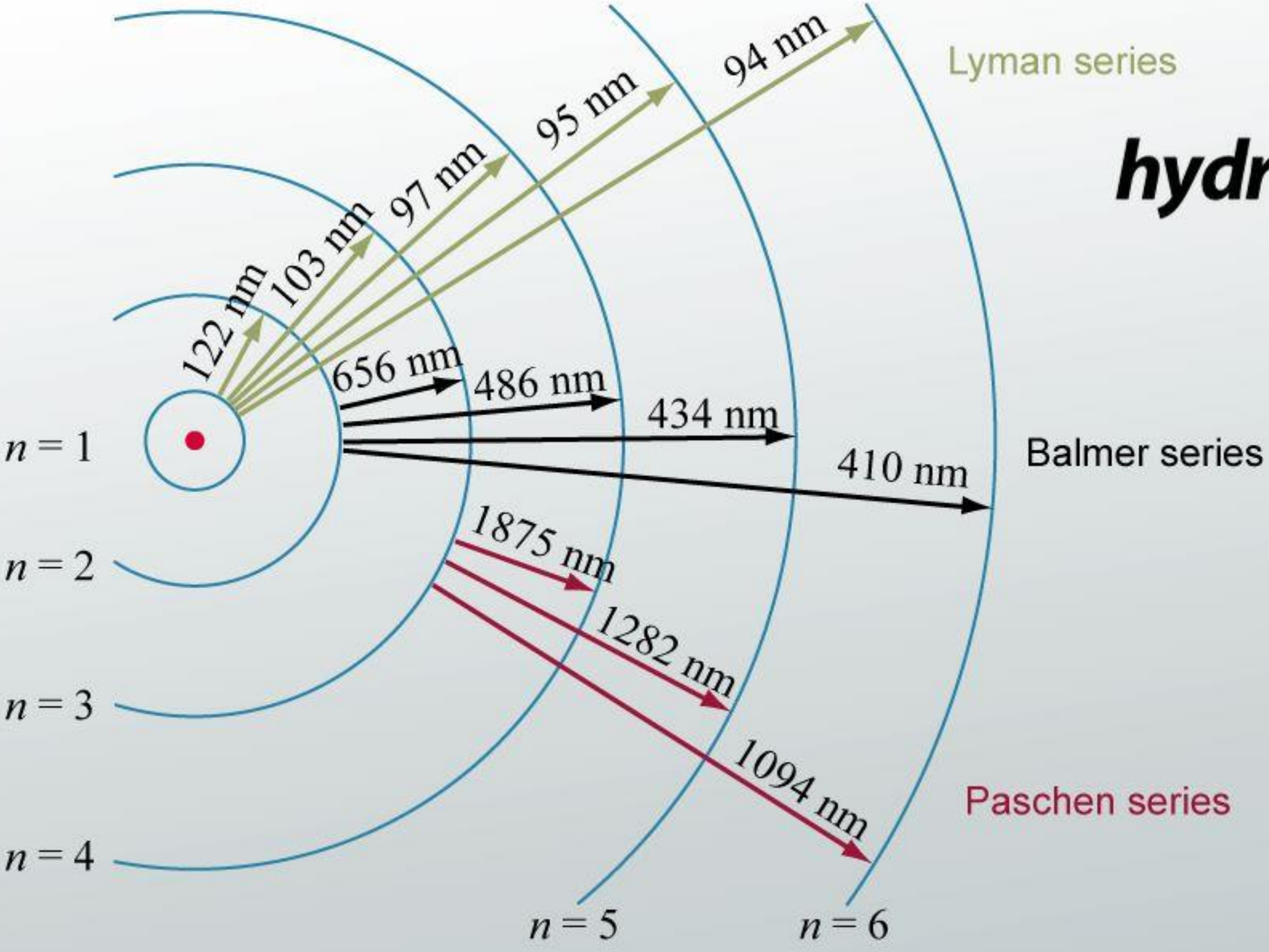
Electron Transitions in Atom Causing Emission Light



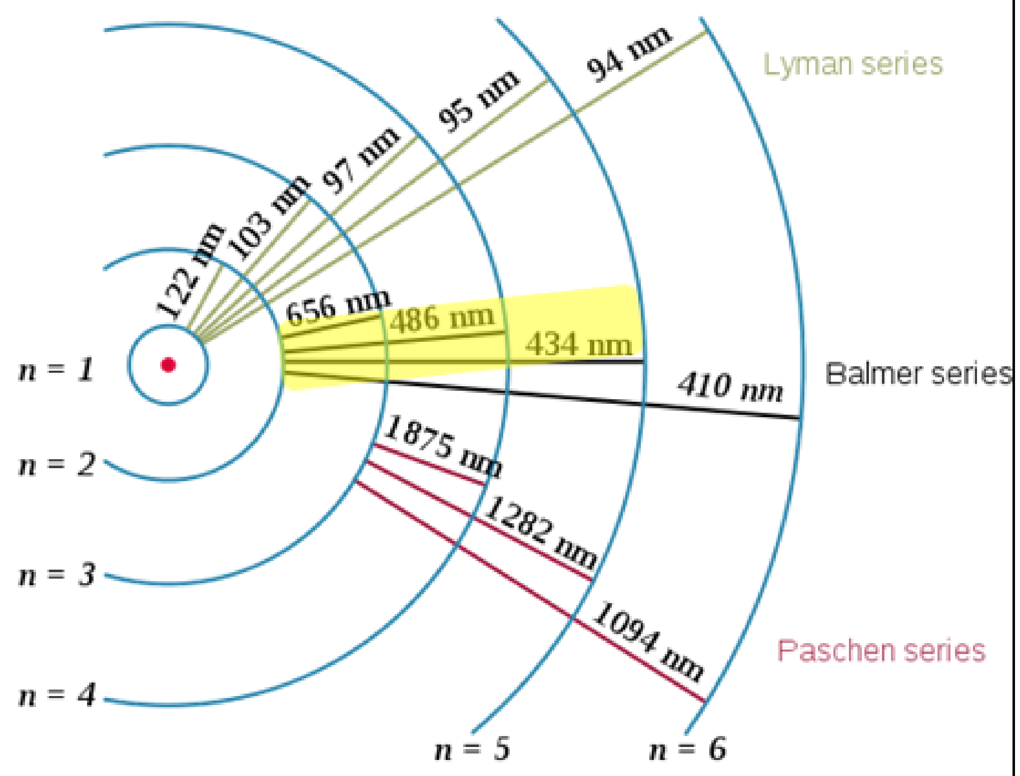




HYDROGEN ATOMS



hydrogen atom



The **Balmer series of** H-absorption lines in stellar spectra are produced when hydrogen atoms in a star's outer layers absorb light (energy) from deeper in the star, making their single electron jump from quantum state n2 to higher states ("outer shells") in the atom. The higher the absorbed photon energy, the longer the jump, resulting in absorption lines ranging from the red to the violet part of the spectrum.

n2→n3	656nm	H-alpha	red
n2→n4	**486nm**	**H-beta**	**cyan**
n2→n5	**434nm**	**H-gamma**	**blue**
n2→n6	410nm	H-delta	violet

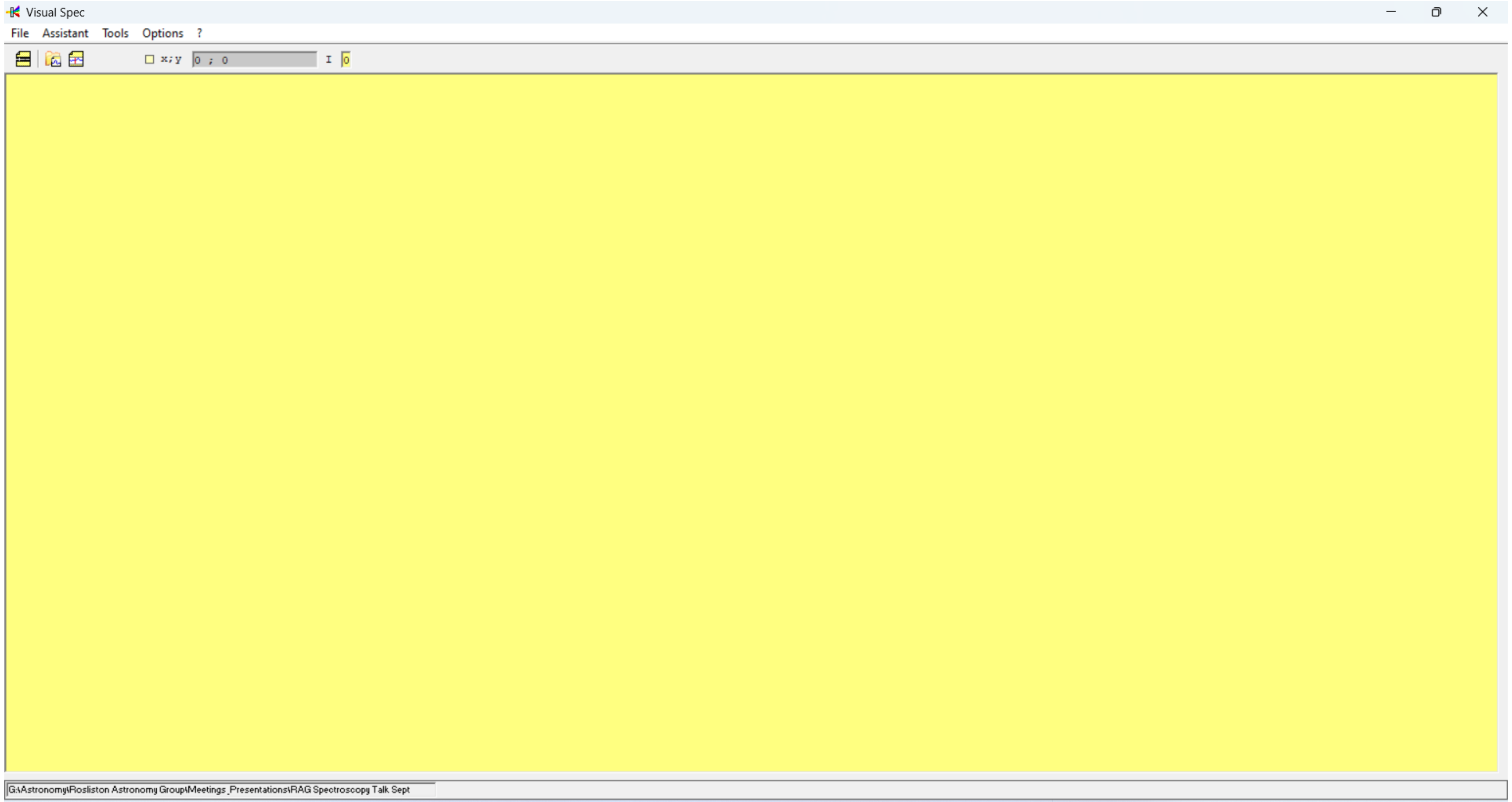
Balmer absorption lines are strongest in stars with a moderate surface temperature of about 10 K kelvin (spectral type A), such as the bright star Vega in the constellation Lyra.

Demonstration VPSEC & taking spectra

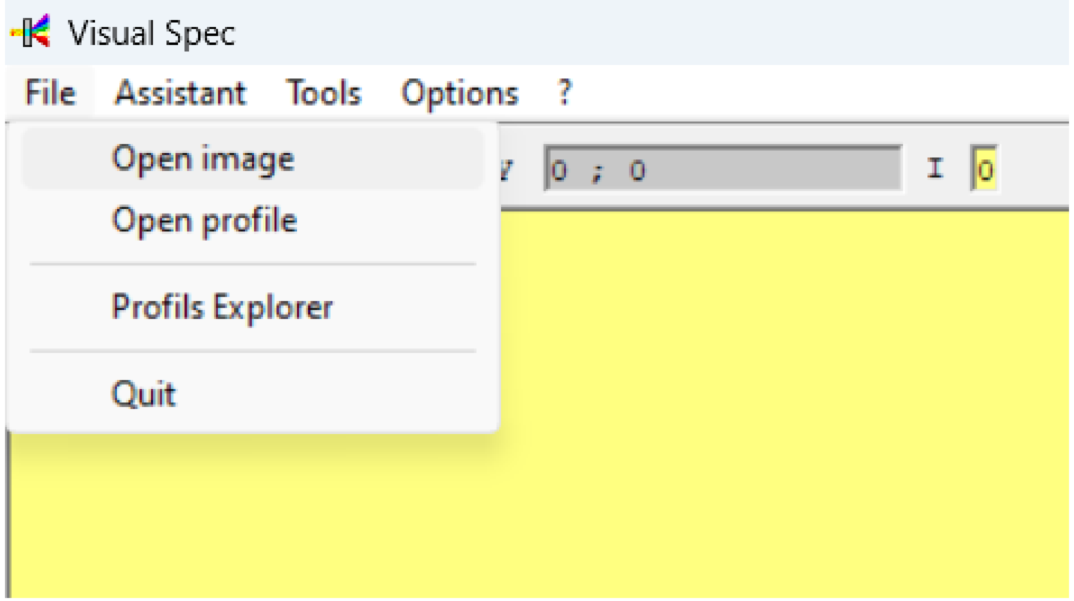
- Software we are going to use is VPSEC (Visual Spec)
- http://www.astrosurf.com/vdesnoux/download.html
- Designed for Windows, sadly no Mac or Linux version.
- Visual Spec has been designed with Visual Basic 6.0 - It has been tested by writers on W95, W98, Vista, Wi7, W10, including 64bits.
- One warning with VPSEC – I have noticed has tendency to crash at least in Windows 11 if illogical action taken by user

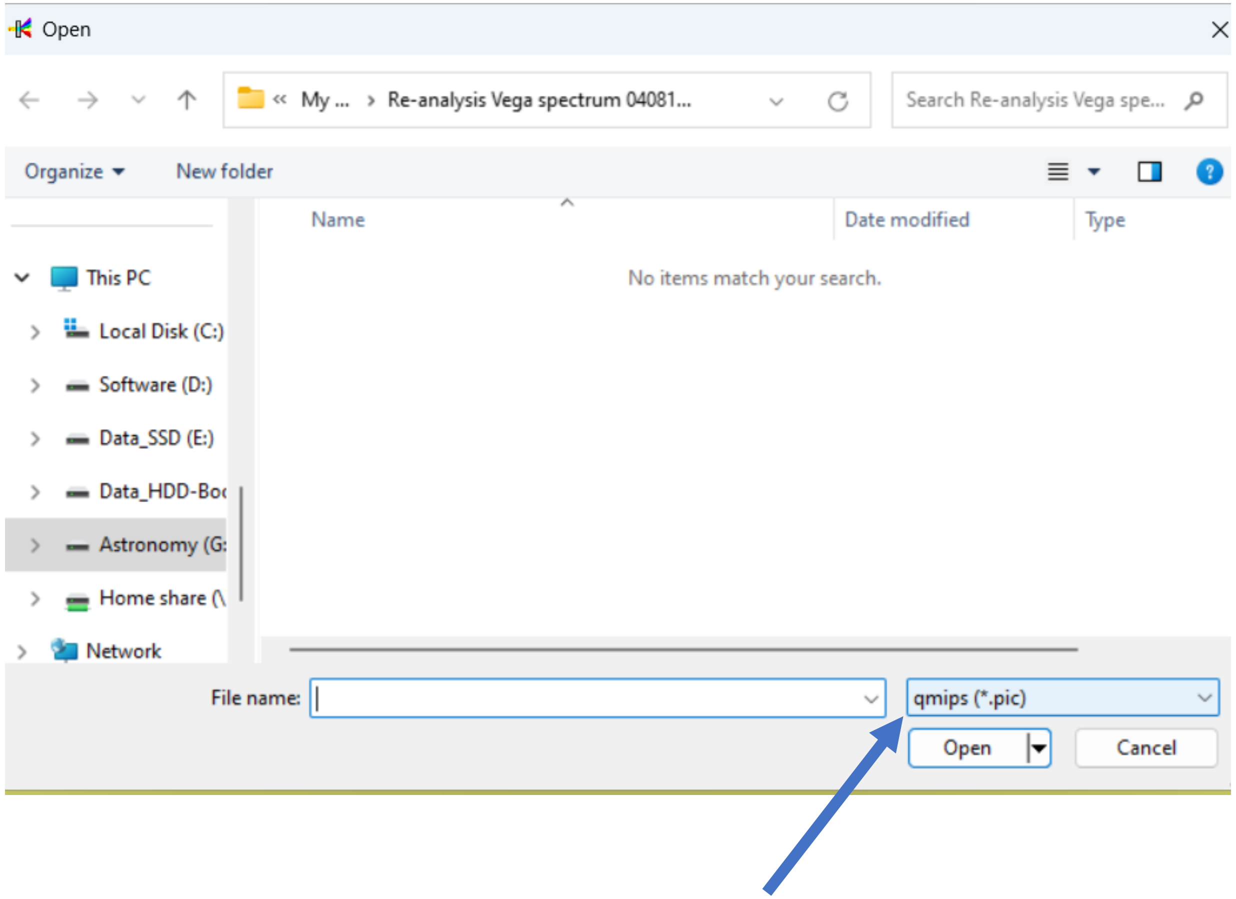
To get a spectrum in VPSEC couldn't be easier

- Start by opening the programme…..



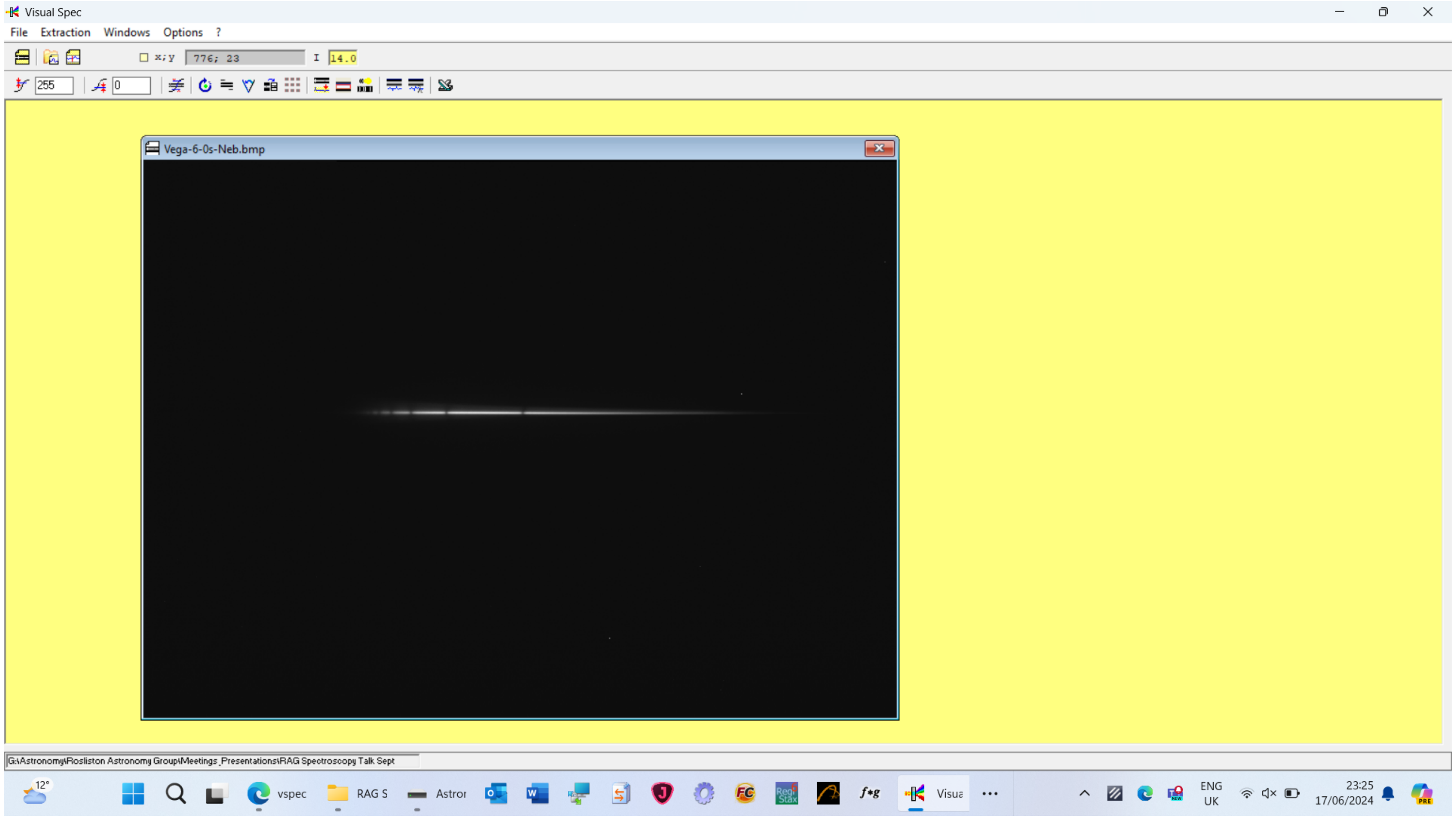
Open an image – File→Open Image



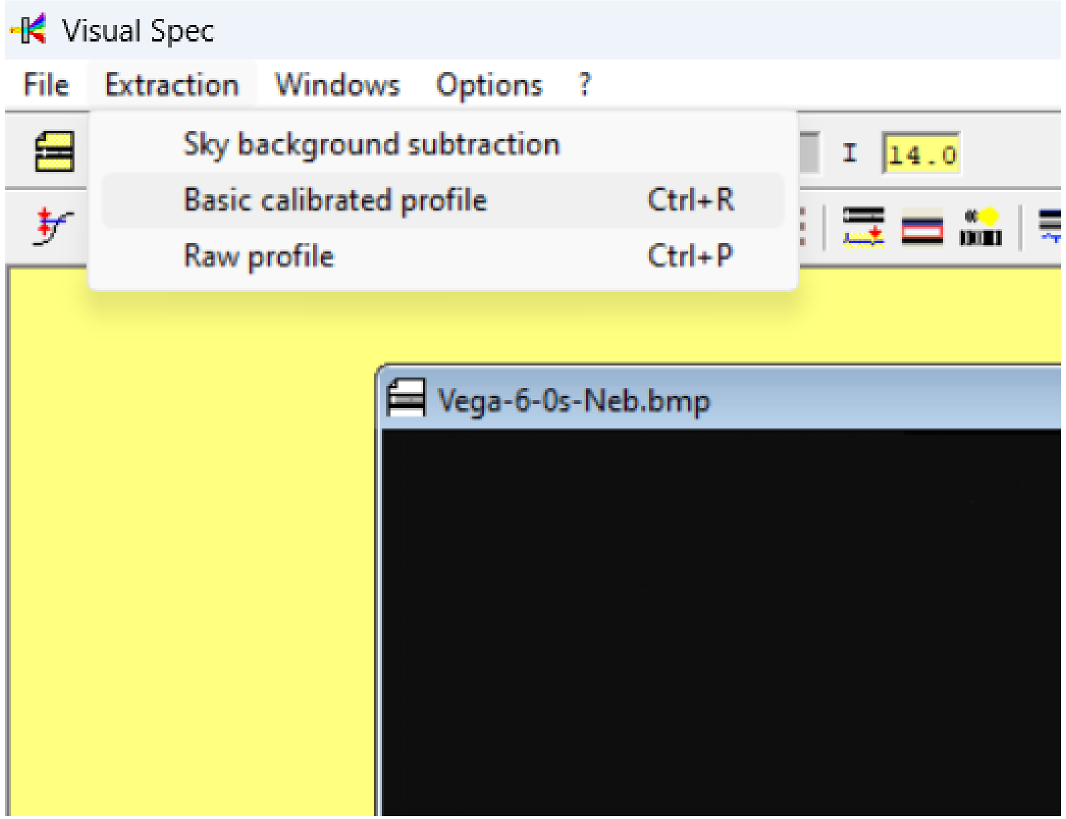


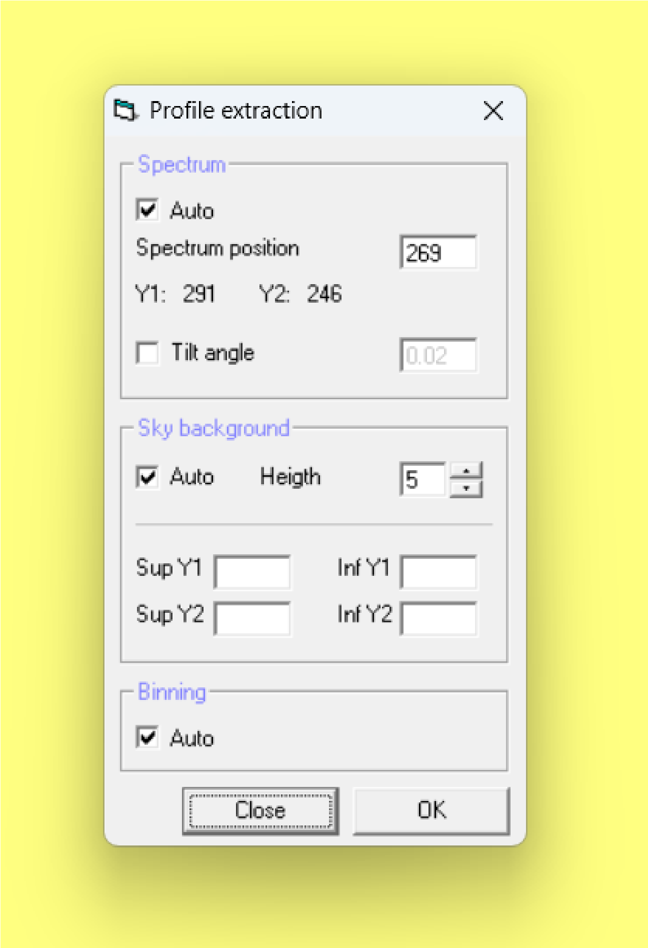
Change image type to FITS or BMP

Select image

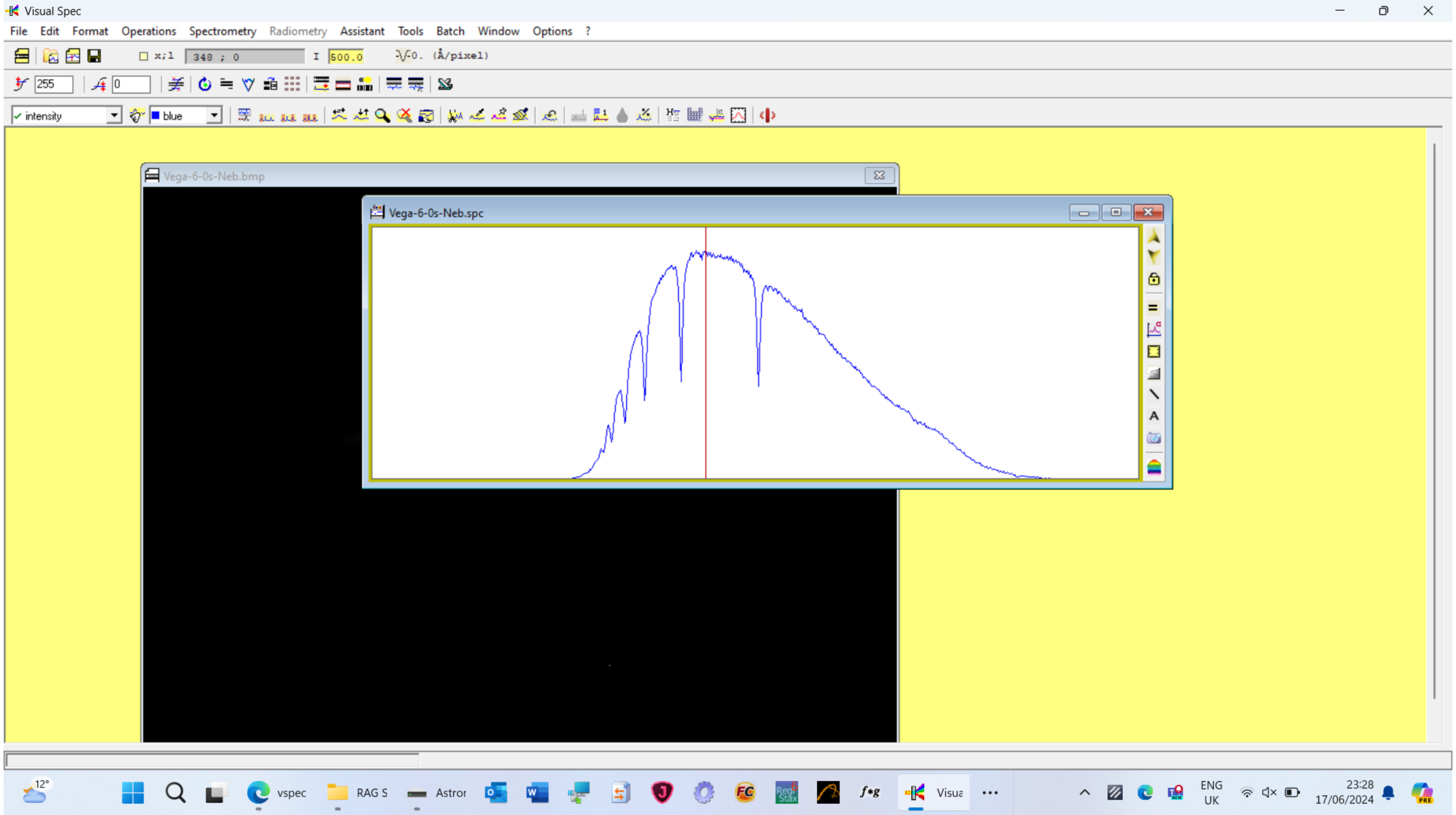


Click Extraction→Basic Image Profile – and ensure automatic ticked





Software automatically creates spectrum!!



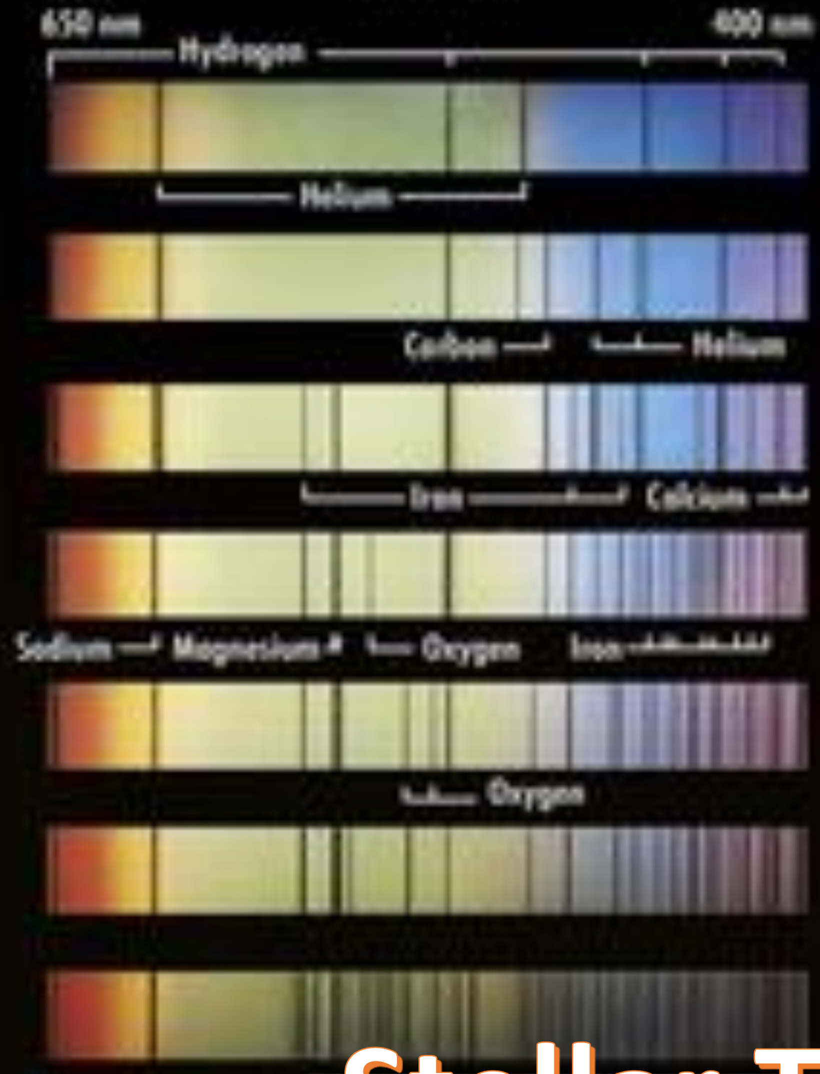
Calibration

- This is NOT like flat frames or dark frames
- Instead, it is method to determine what the wavelengths (frequencies) are in the spectra you record with your telescope and spectrometer.
- You take a spectrum of a light source, where you are able to identify main spectral lines and know their wavelengths, using the same telescope/spectrometer/camera setup that you use for your other spectra/your data.
- In the spectroscopy software, you label the known wavelengths (usually two are required) on the calibration data.
- The software will now calculate the wavelengths on other plots foryou, allowing you to identify spectral lines on those plots.

Calibration – Compact Fluorescent Light Bulb (CFL)

Similar to other fluorescent lighting: electrons that are bound to mercury atoms that are excited to states where they will radiate ultraviolet light as they return to a lower energy level; this emitted ultraviolet light is converted into visible light as it strikes the fluorescent coating, and into heat when absorbed by other materials such as glass.

STELLAR CLASSIFICATION (MAIN-SEQUENCE)



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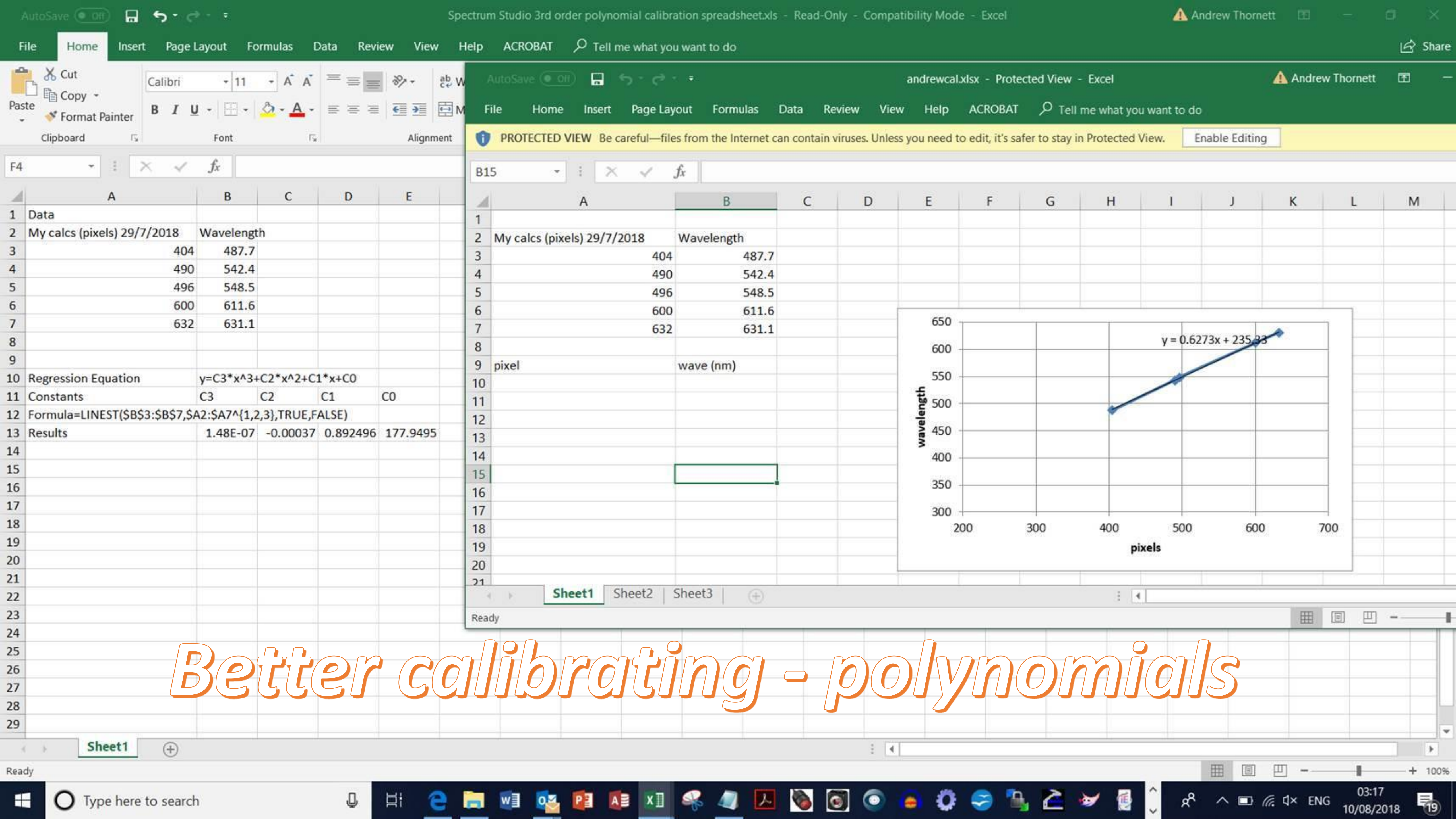
Stellar Type vs Spectrum

Better calibrating - polynomials



Demonstration of calibration
Using VSPEC (Visual Spec)

Now it's your turn to have a go!