

# Observing the Small White Dots

*The Analysis of Starlight*

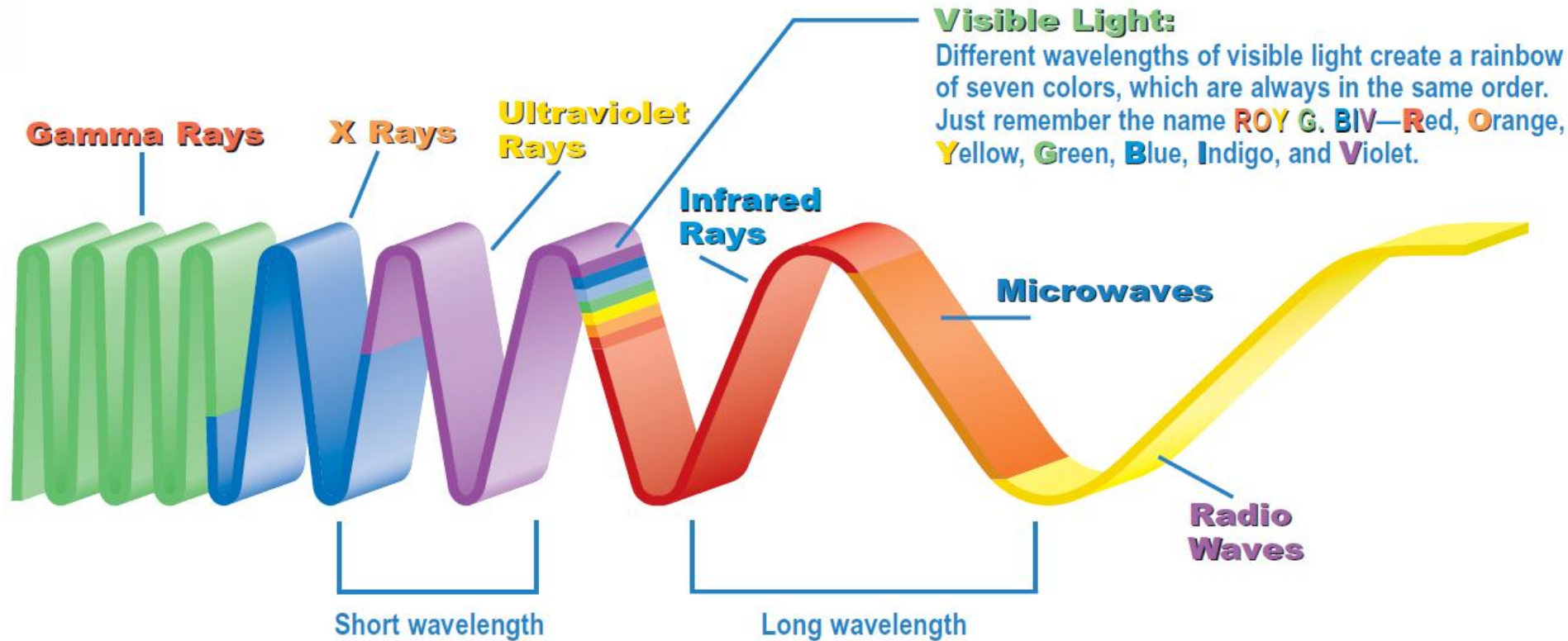


David Haworth - [www.stargazing.net/david](http://www.stargazing.net/david)



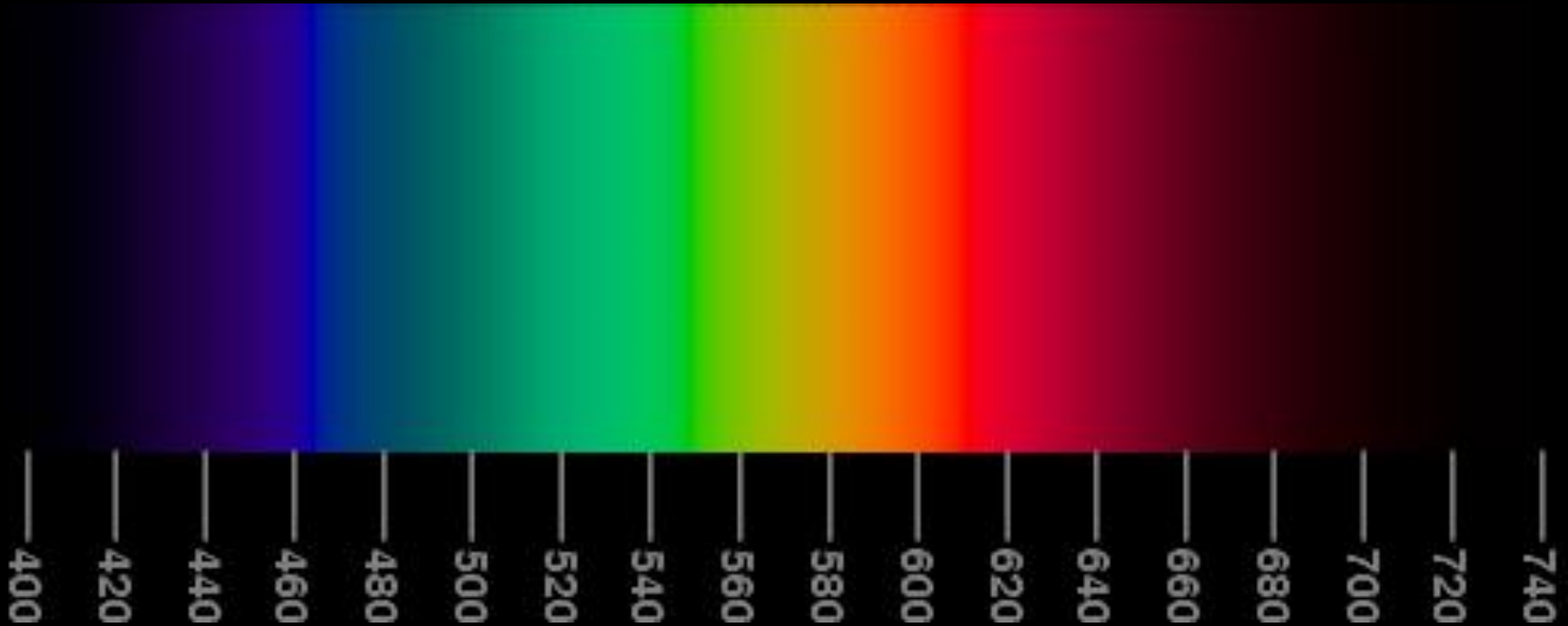
# Light

## Electromagnetic Spectrum



Wavelength measured in nanometers =  $10^{-9}$  meter (nm) =  $10 \text{ \AA}$   
or angstroms =  $10^{-10}$  meter ( $\text{\AA}$ ) = 0.1 nm

# Light Dispersion Spectrum



Wavelength in nanometers

# Solar Screwdriver CD Spectroscop

[www.stargazing.net/david/spectroscopy/ScrewdriverCDROMSpectroscope.html](http://www.stargazing.net/david/spectroscopy/ScrewdriverCDROMSpectroscope.html)

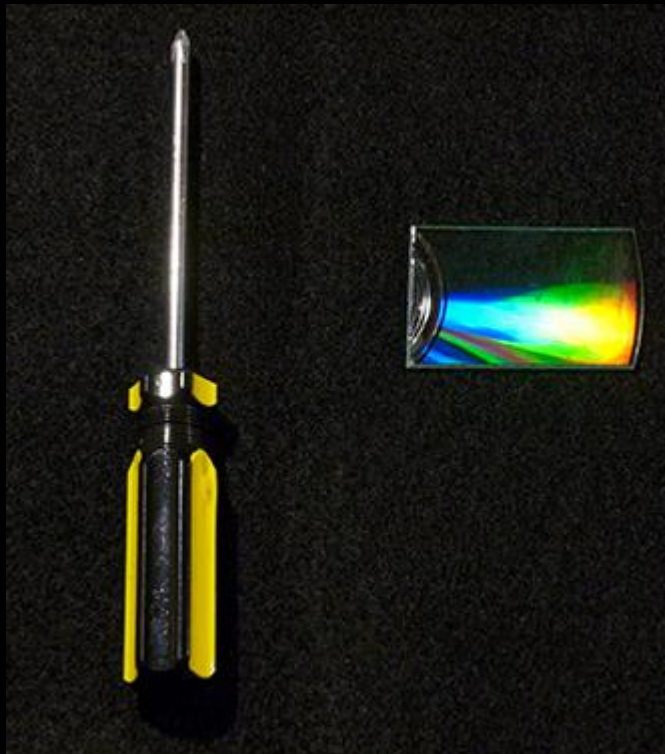


**Do NOT look directly at the Sun**

# Solar Screwdriver CD Spectroscope

3 inch mailing tube

- Cut up CD with label removed
- Round screwdriver for reflecting the Sun

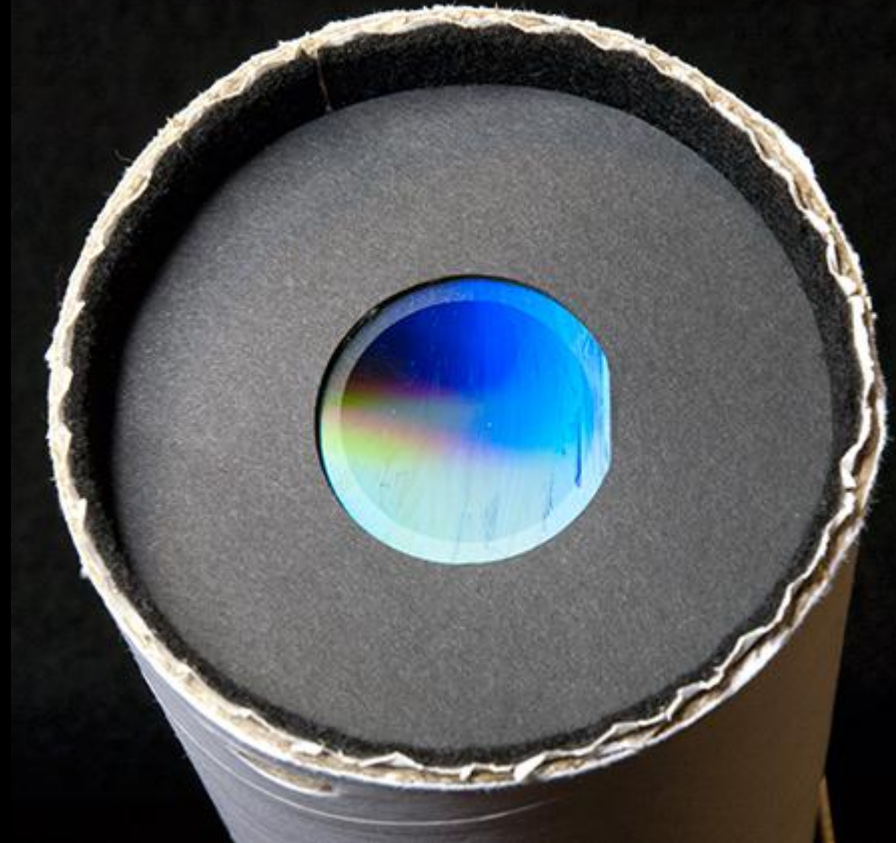
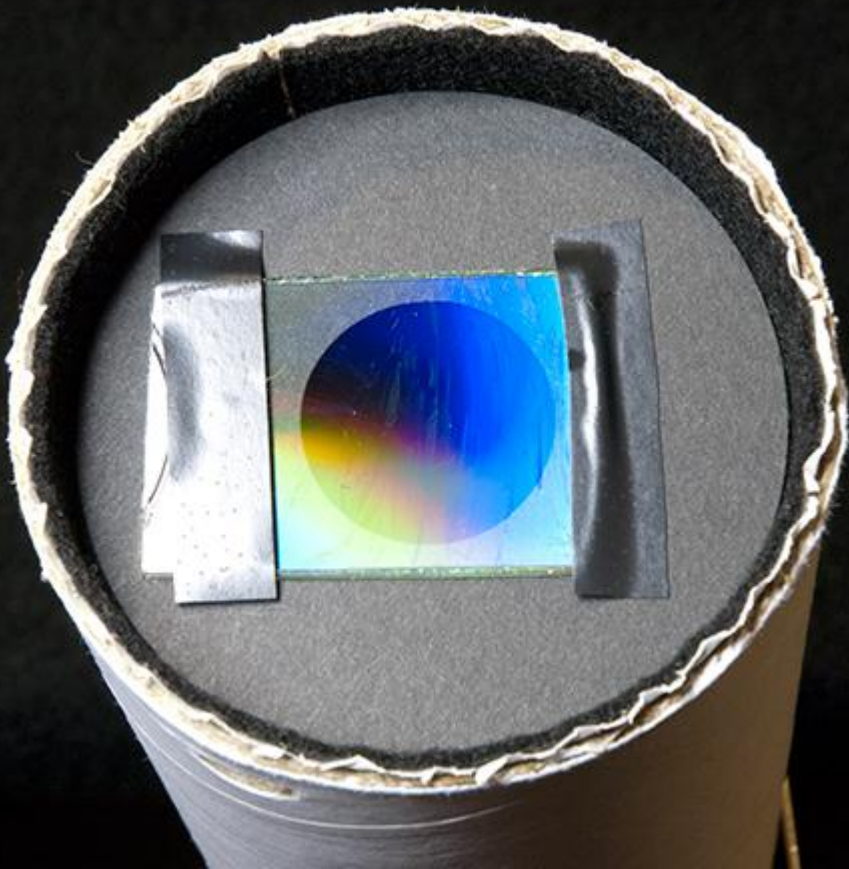


**Do NOT look directly at the Sun**

# Solar Screwdriver CD Spectroscope

Black felt in side the tube

- 👁️ CD is a  $>600$  line/mm transmission grating

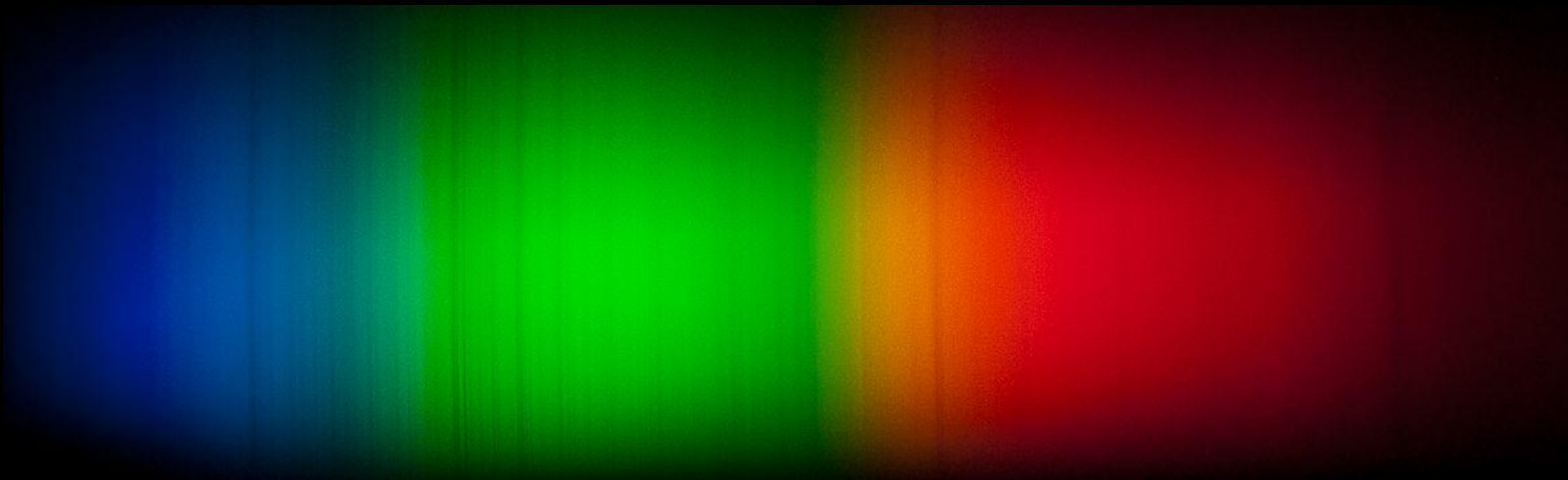


**Do NOT look directly at the Sun**

# Solar Spectrum



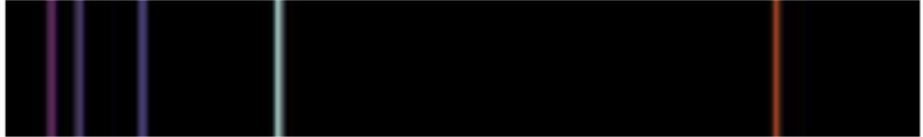
Screwdriver CD Spectroscope

- 🌀 Dark absorption lines
- 🌀 Camera focus on green part of the spectrum



# 3 Types of Spectra

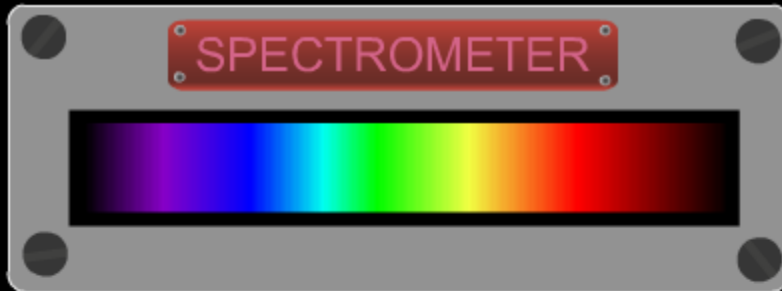
Kirchoff radiation continuous law

Type of Spectrum	Photographic example
Continuous (or continuum)	
Absorption (dark line)	
Emission (bright line)	

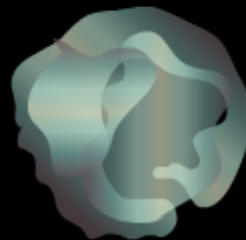


# Continuous Spectrum

Kirchoff radiation continuous law



Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.



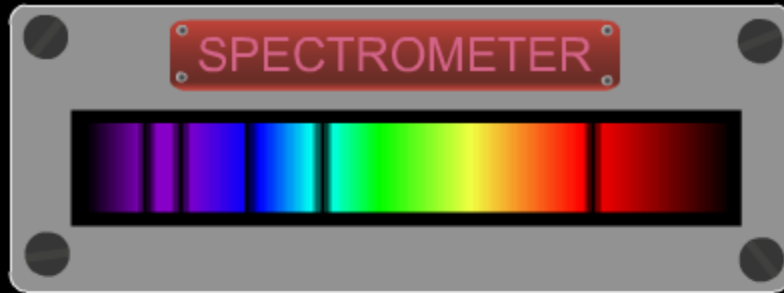
Star atmosphere,  
Nebula, etc.



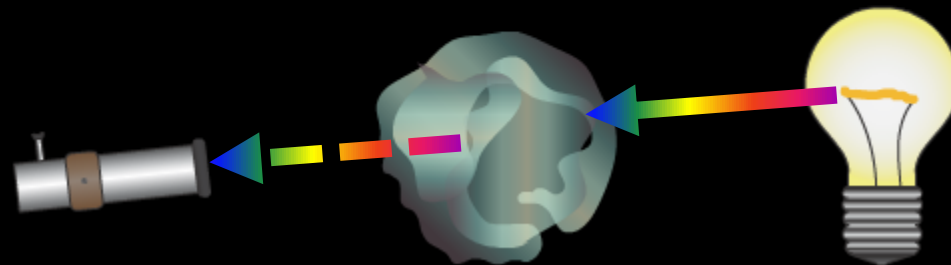
Star

# Absorption Spectrum

Kirchoff radiation absorption law



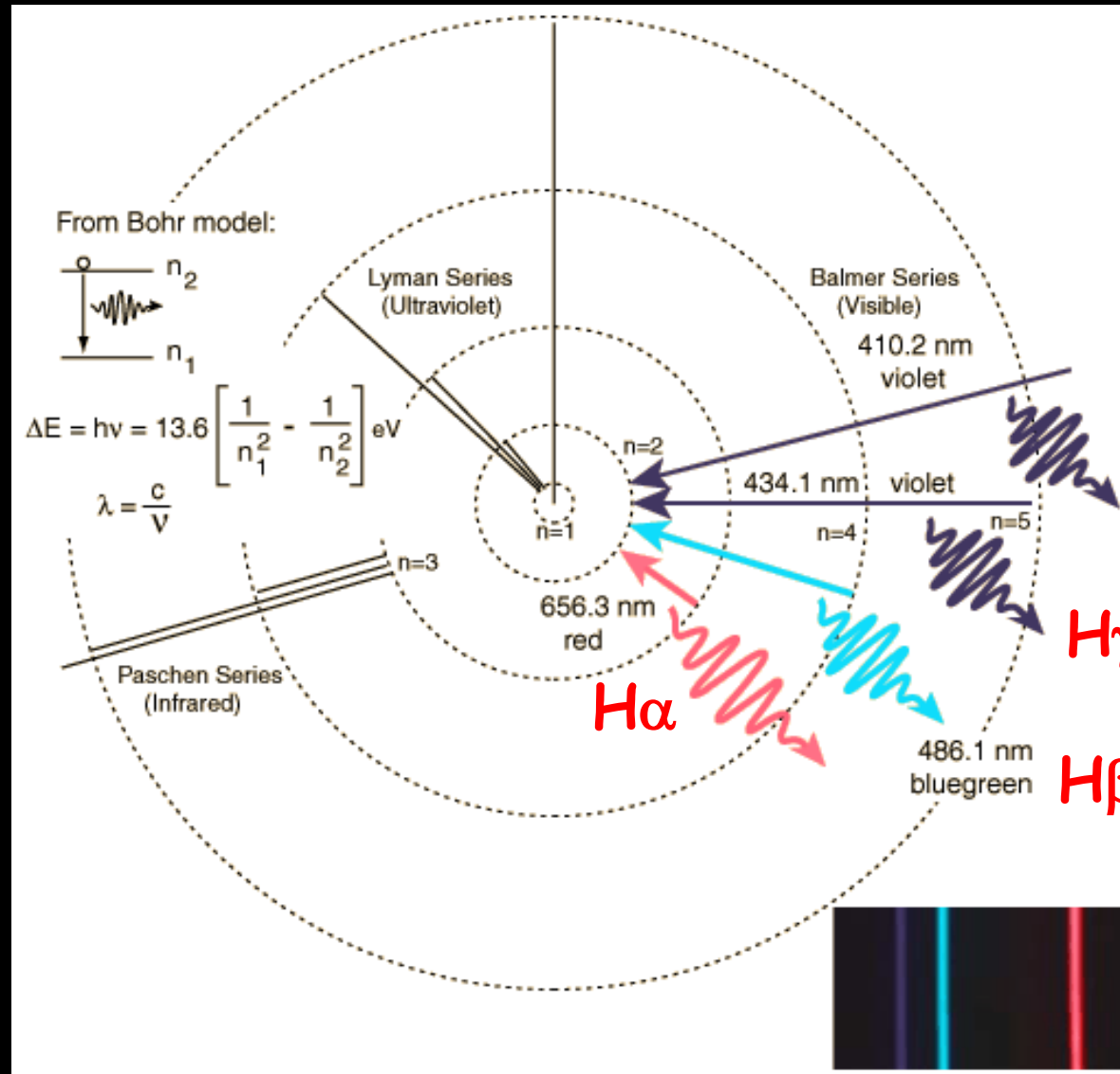
Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.



Star atmosphere,  
Nebula, etc.

Star

# Hydrogen Atom Energy Levels

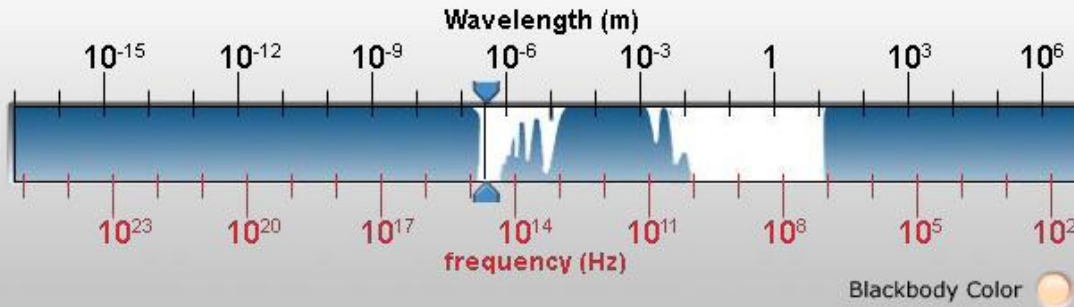


# Element Spectral Patterns

Each element has unique spectral absorption/emission lines

- ① Each element has unique number of
  - ① Electrons
  - ① Protons
  - ① Neutrons
- ① Each element has unique set of energy levels
- ① Energy levels maps into unique set of spectral absorption/emission lines

# Electromagnetic Spectrum



## Spectrum Screen

Wavelength =  $6.600 \times 10^{-7}$  m

Visible

Frequency =  $4.545 \times 10^{14}$  Hz

$E = h * f = 3.000 \times 10^{-19}$  Joule

## Size



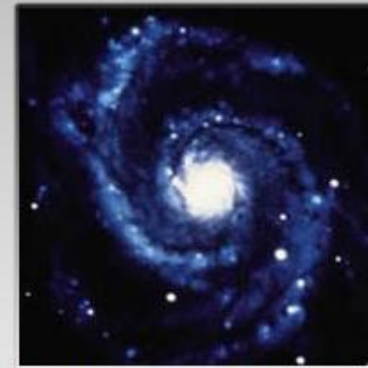
Dust

## Instrument



Hubble Space Telescope

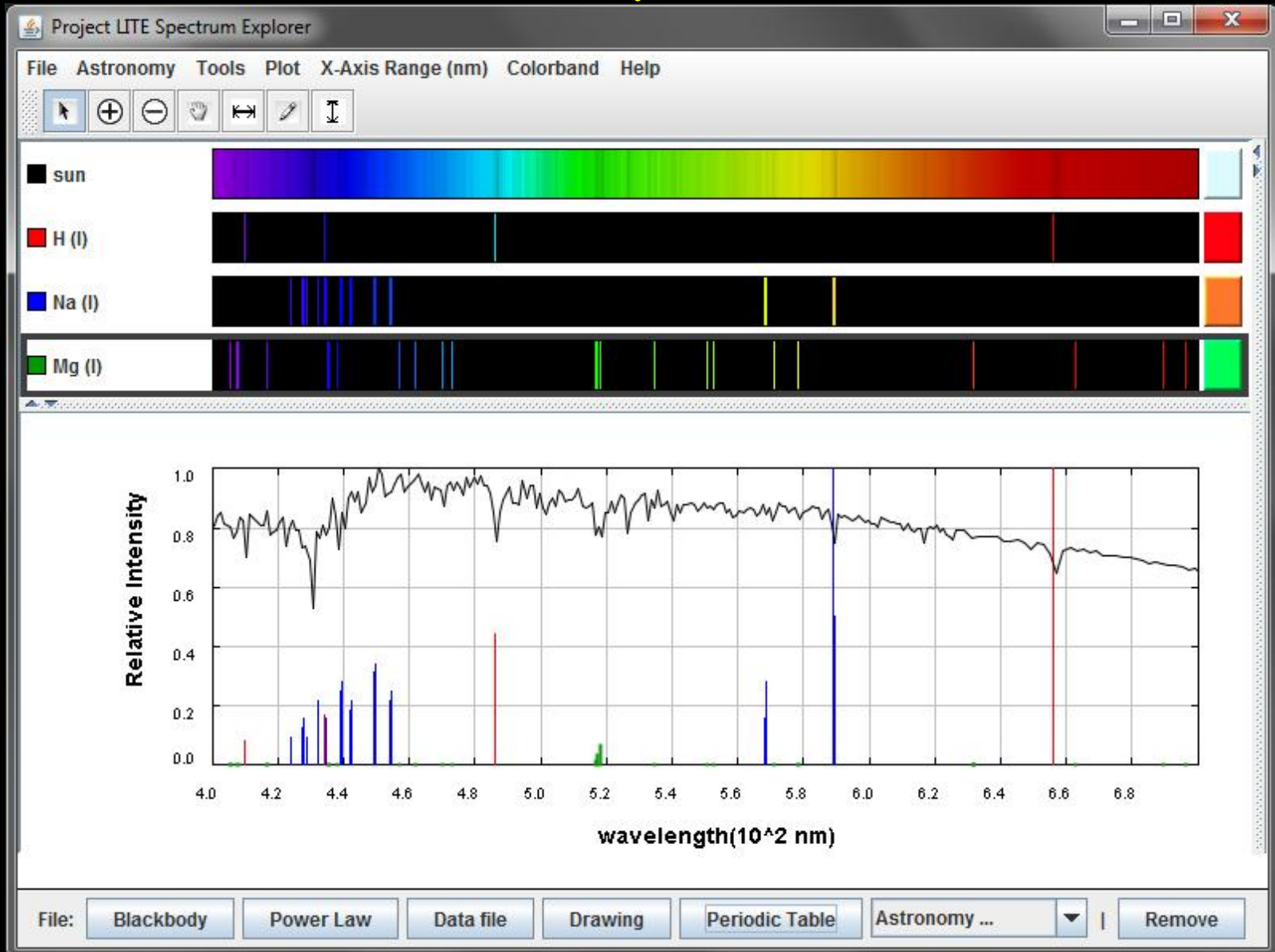
## Astronomy Picture



Visual Image of Spiral Galaxy M51



# Solar Spectrum

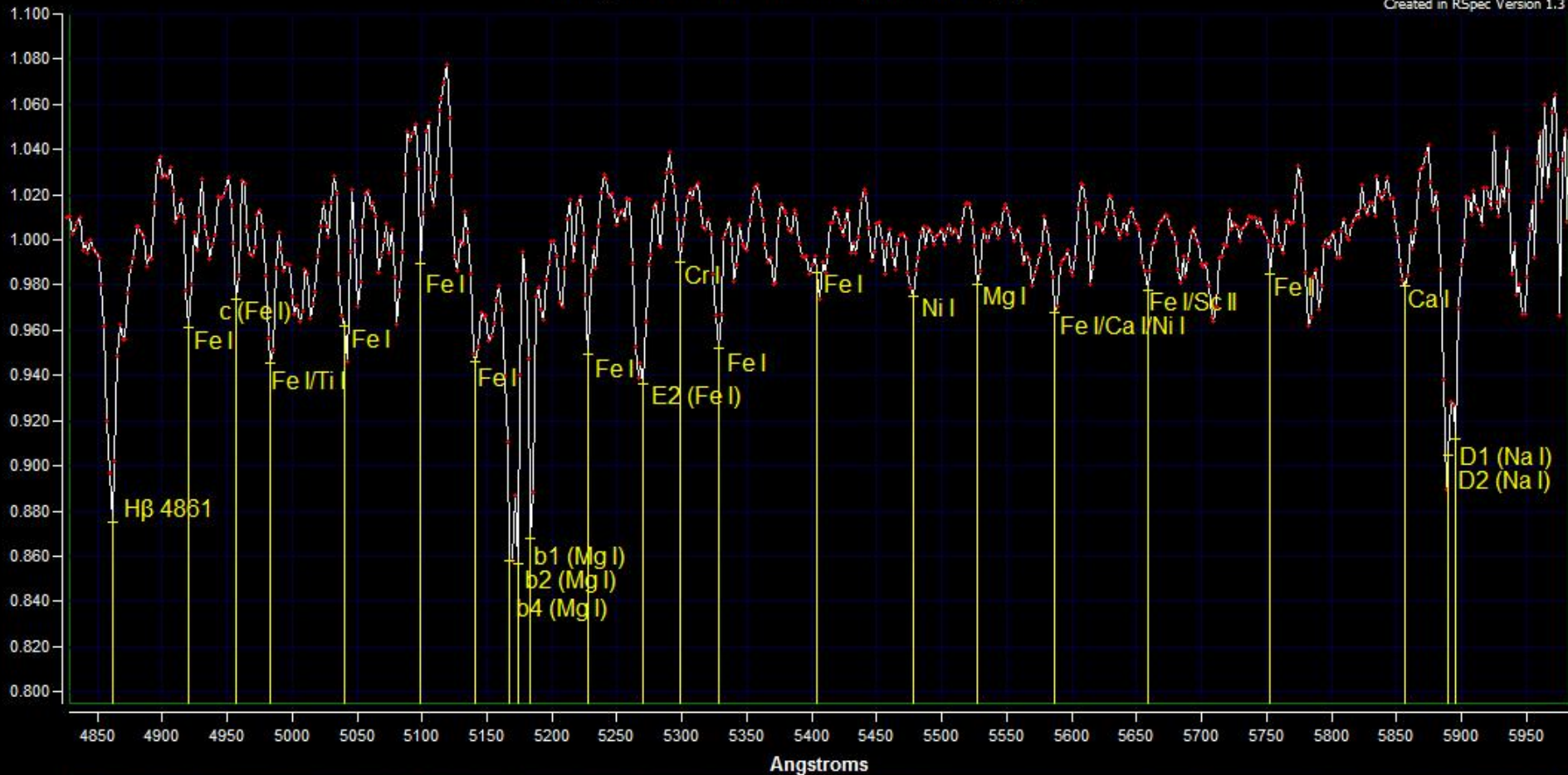


# Screwdriver CD Sun Spectrum

## Absorption lines from H $\beta$ to Na doublet

Sun (Screwdriver & CD Spectroscope)

Created in RSpec Version 1.3



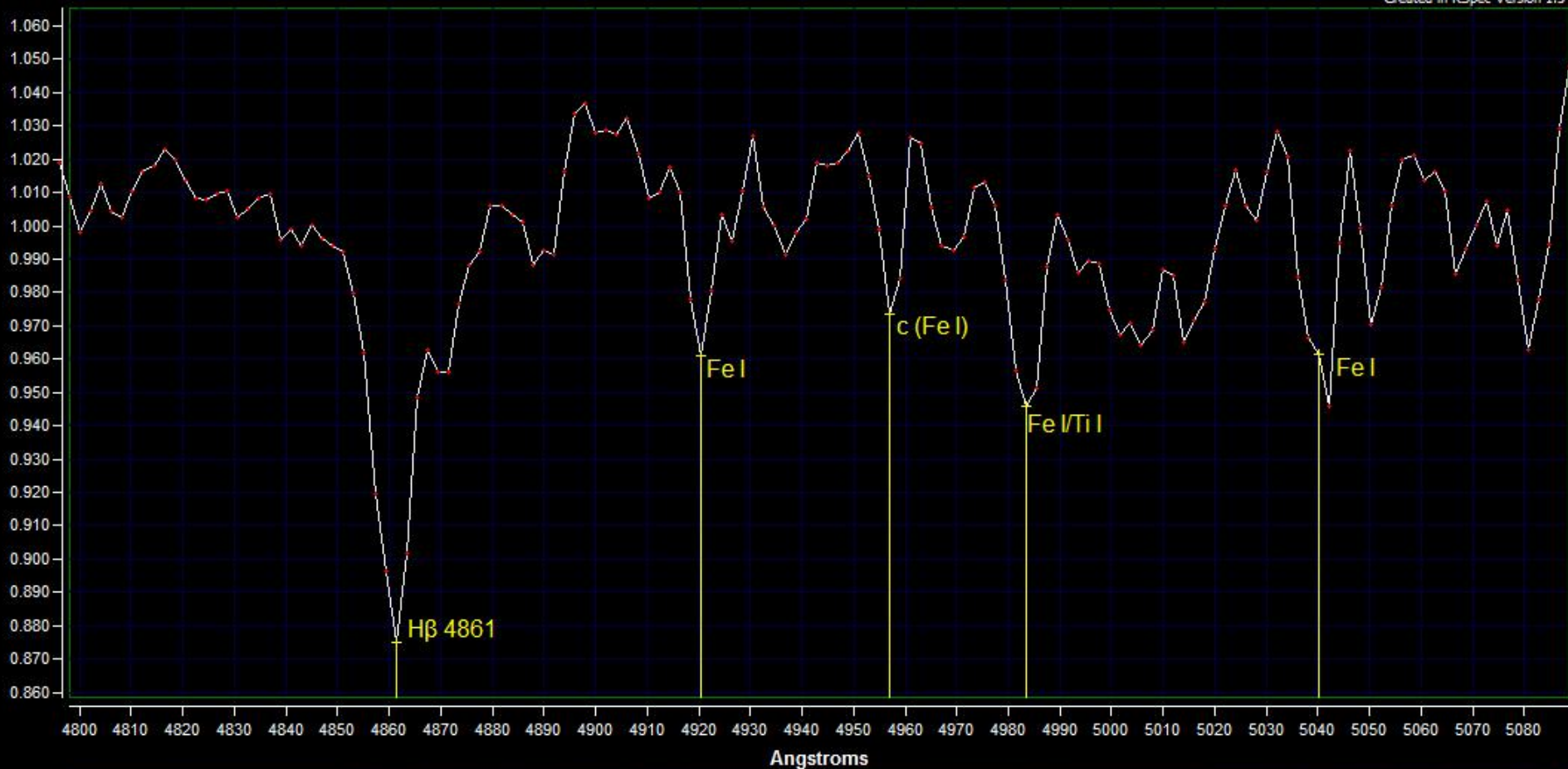


# Screwdriver CD Sun Spectrum

## H $\beta$ absorption line

Sun (Screwdriver & CDROM Spectroscope)

Created in RSpec Version 1.3

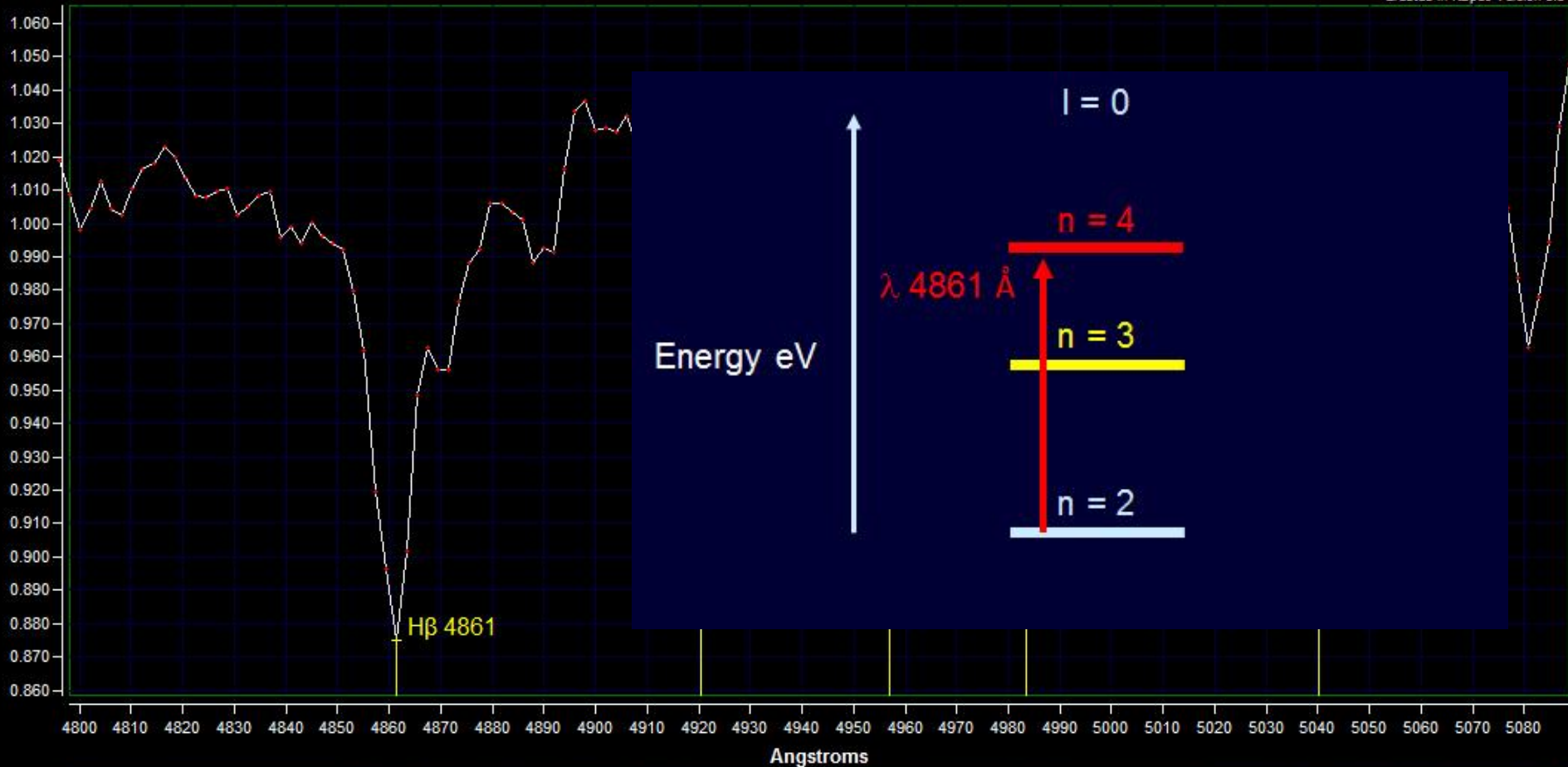


# Screwdriver CD Sun Spectrum

H $\beta$  absorption line is a transition from  $n = 2$  to  $n = 4$

Sun (Screwdriver & CDROM Spectroscope)

Created in RSpec Version 1.3

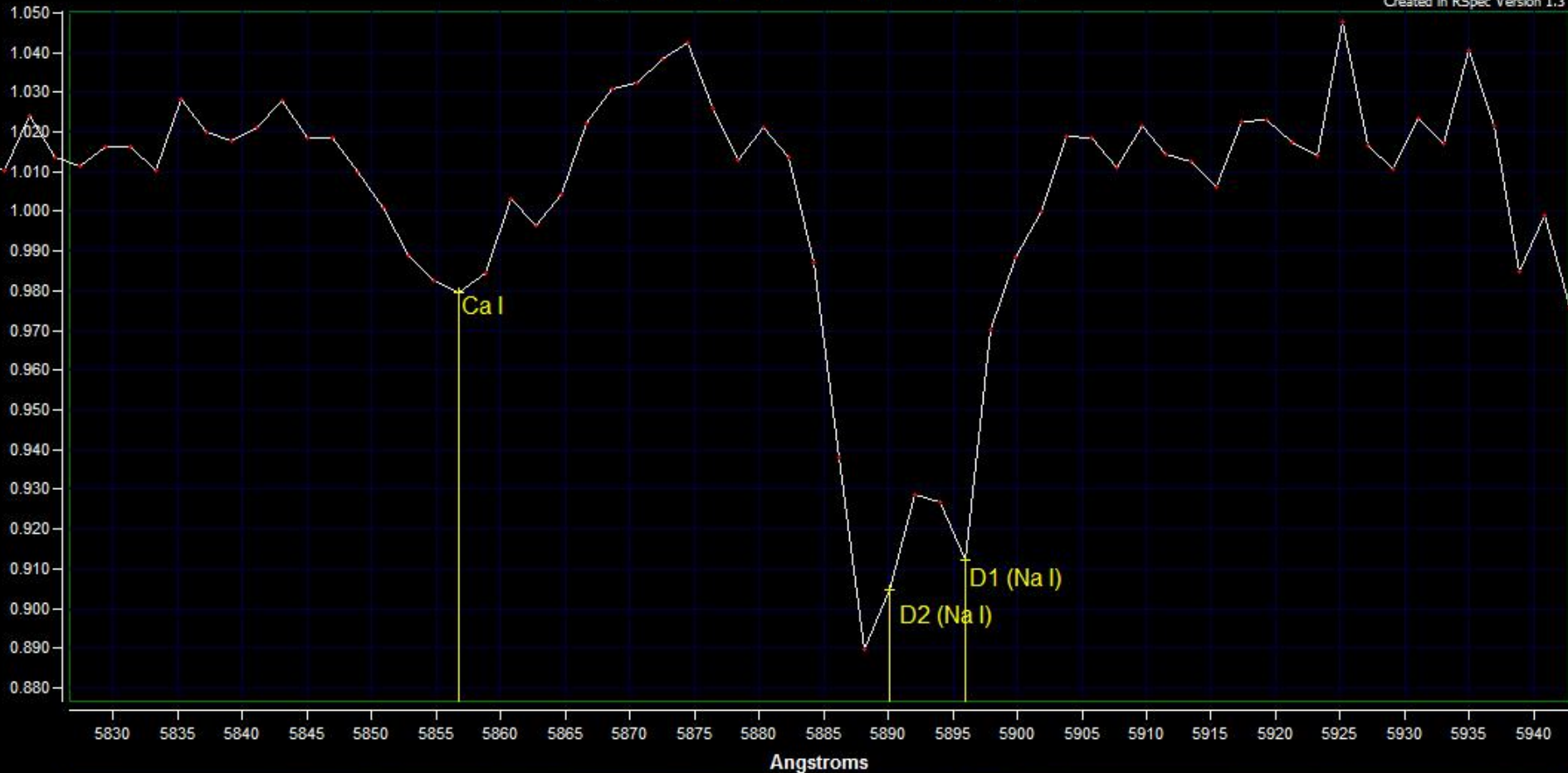


# Screwdriver CD Sun Spectrum

## Na doublet absorption lines

Sun (Screwdriver & CD Spectroscopie)

Created in RSpec Version 1.3

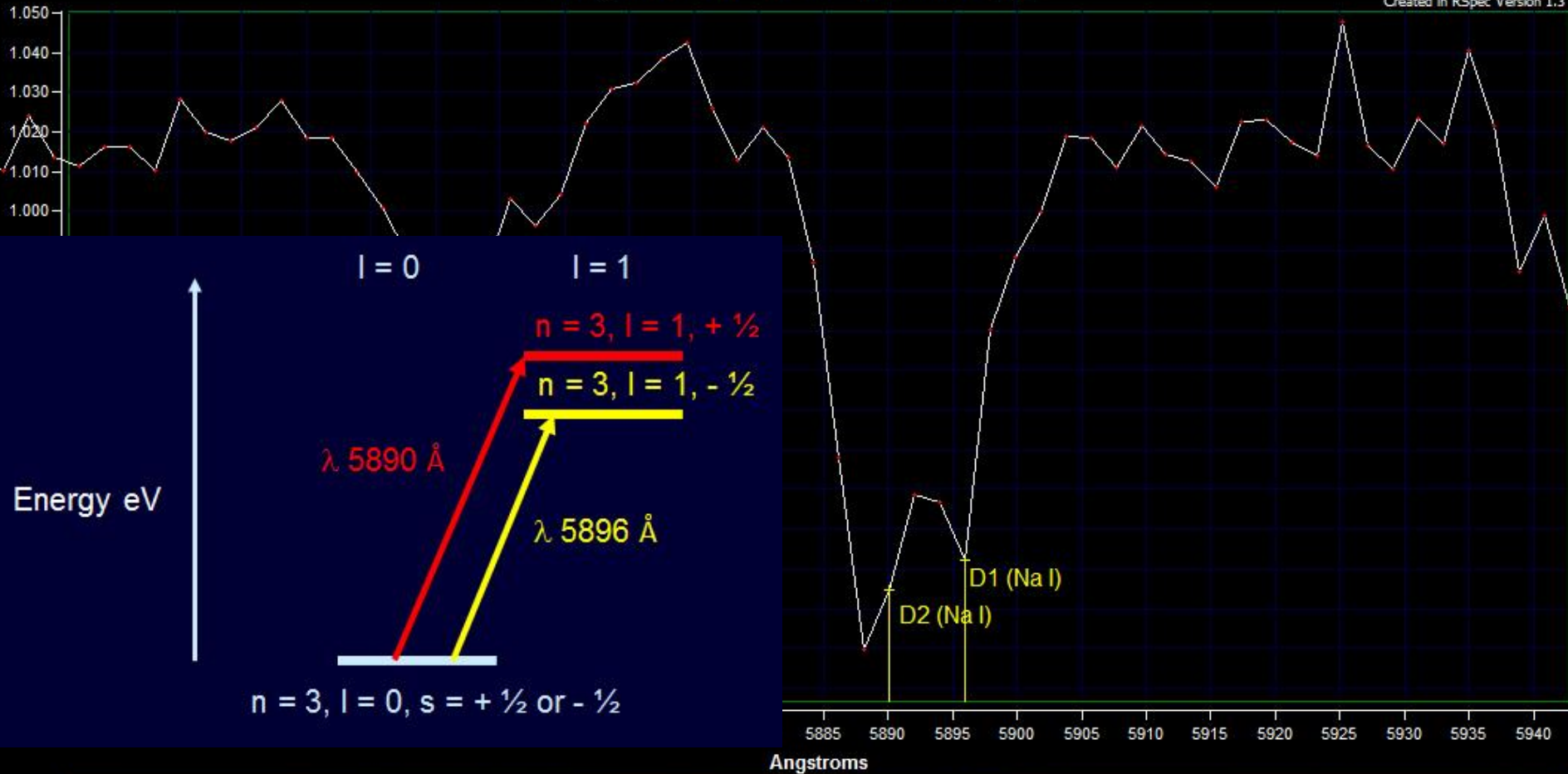


# Screwdriver CD Sun Spectrum

## Na doublet absorption lines

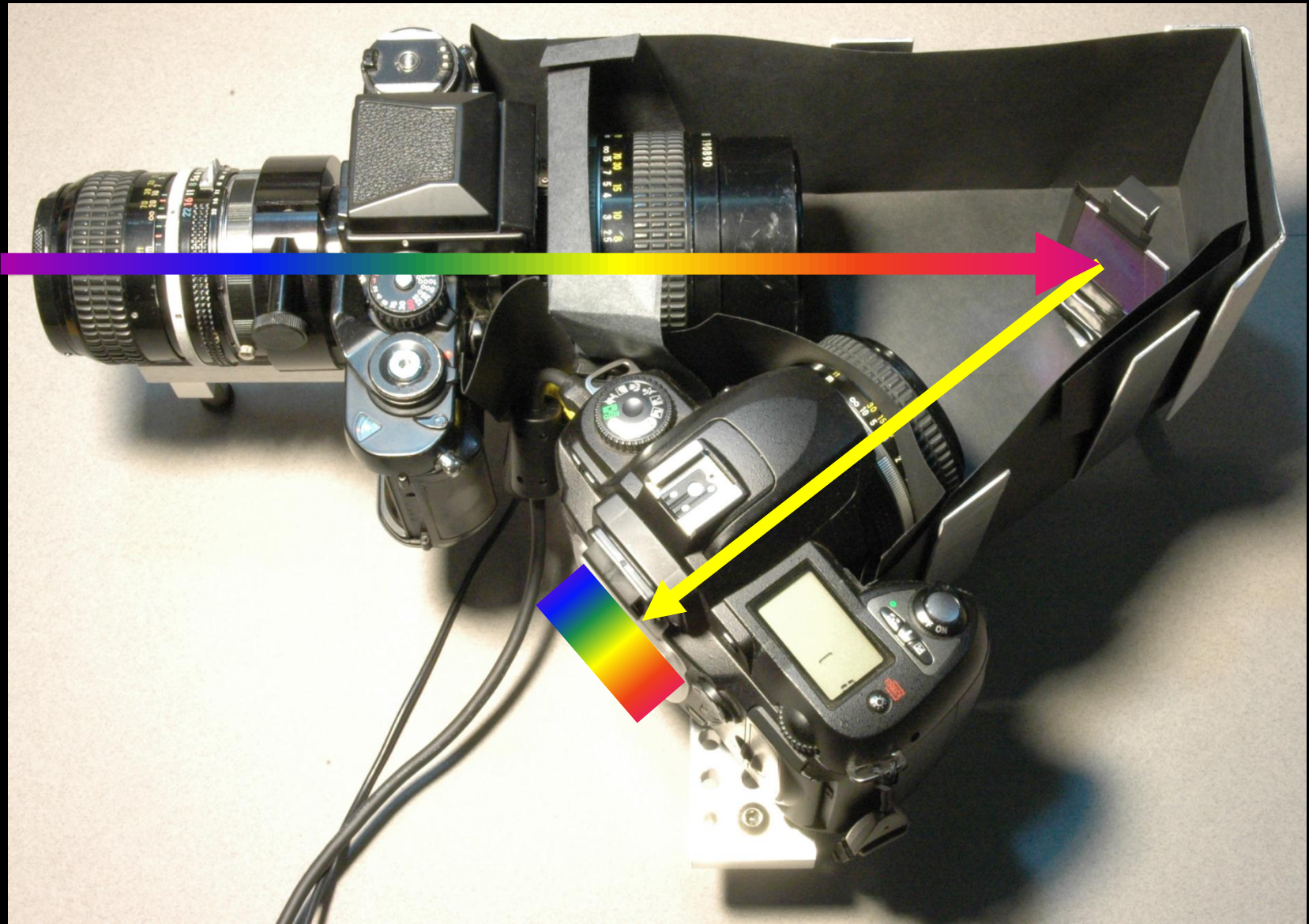
Sun (Screwdriver & CD Spectroscope)

Created in RSpec Version 1.3



# 38° Classical Spectrograph

Nikon Camera Parts DVD Spectrograph



# Fraunhofer Solar Lines

DVD Spectrograph



G: Ca, Fe, H<sub>γ</sub>  
|

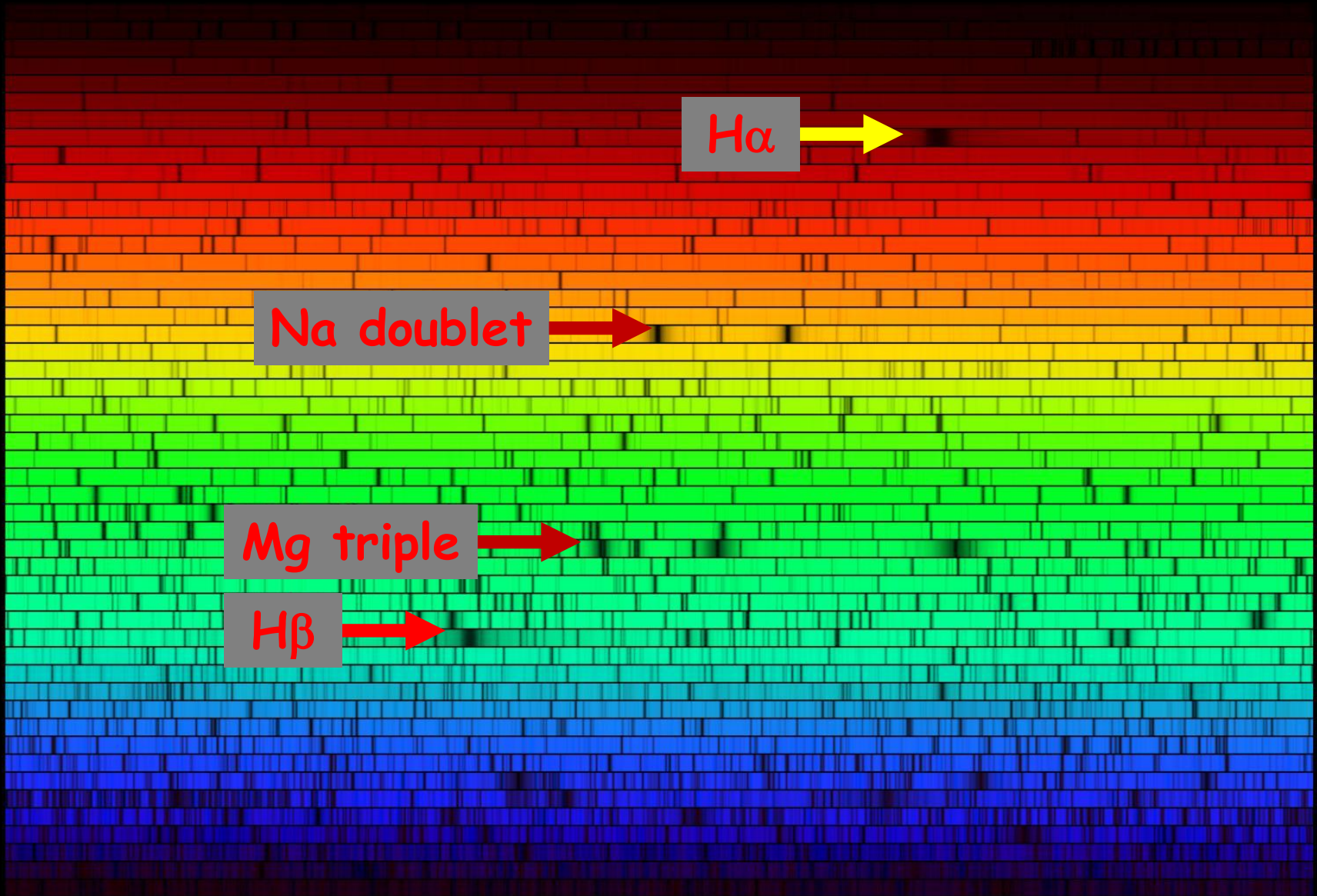
F: H<sub>β</sub>  
|

b: Mg  
|

E: Fe  
|

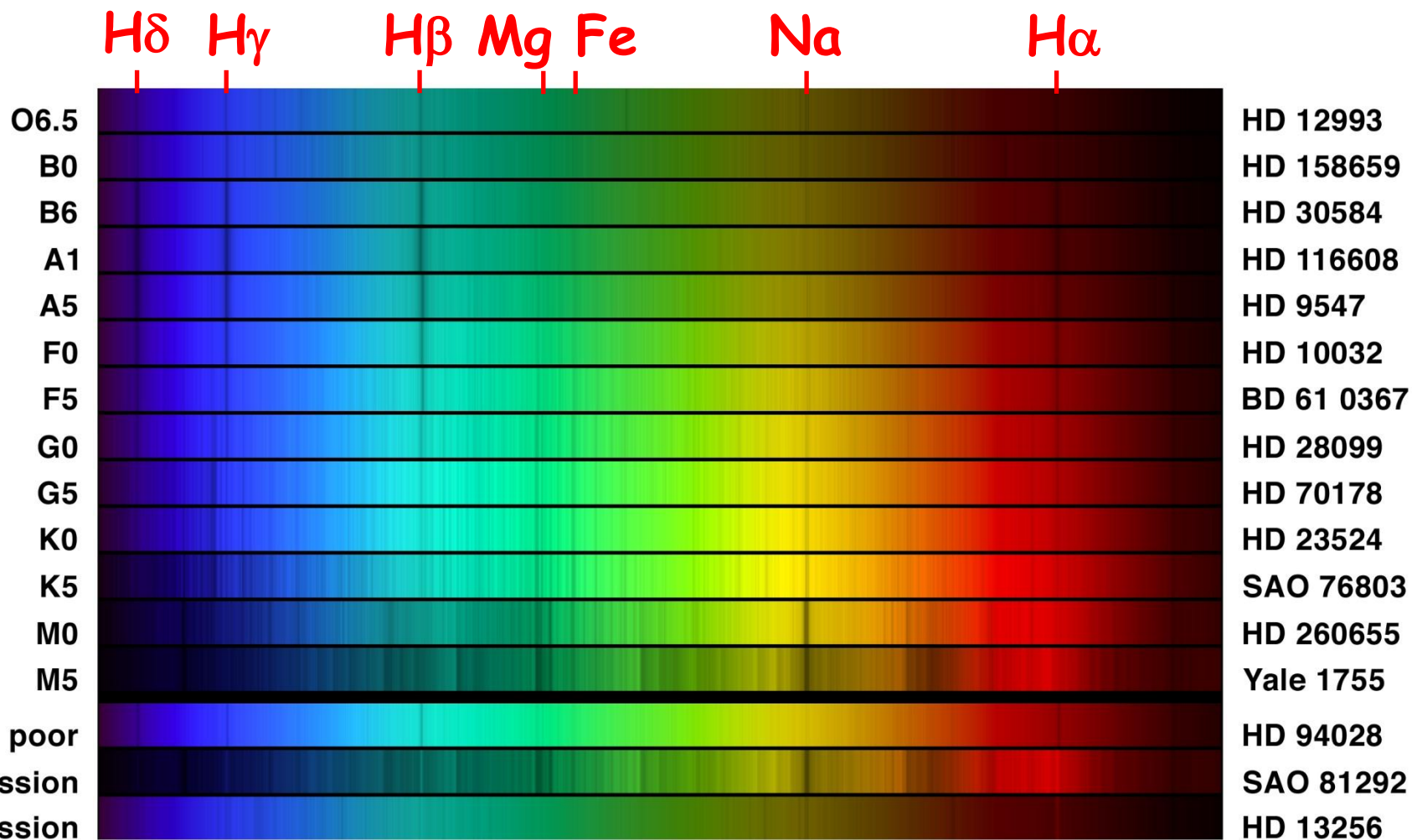
D: Na  
|

# High Resolution Solar Spectrum



# Spectral Classification

OBAFGKM

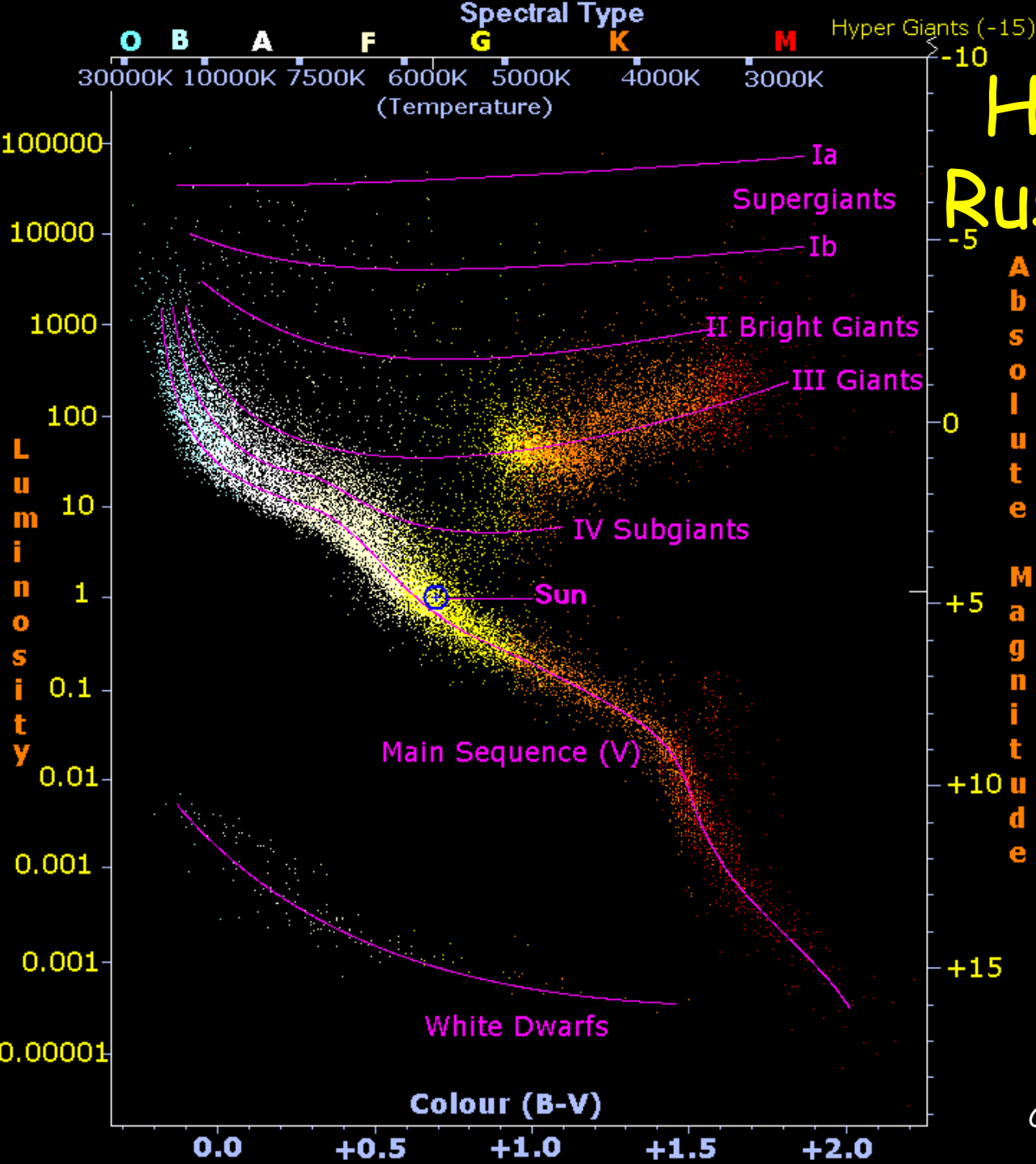




# Star Spectral Classification

OBAFGKM

Spectral Class	Effective Temperature (K)	Colour	H Balmer Features	Other Features	$M/M_{\text{Sun}}$	$R/R_{\text{Sun}}$	$L/L_{\text{Sun}}$	Main Sequence Lifespan
O	28,000 - 50,000	Blue	weak	ionised He <sup>+</sup> lines, strong UV continuum	20 - 60	9 - 15	90,000 - 800,000	1 - 10 Myr
B	10,000 - 28,000	Blue-white	medium	neutral He lines	3 - 18	3.0 - 8.4	95 - 52,000	11 - 400 Myr
A	7,500 - 10,000	White	strong	strong H lines, ionised metal lines	2.0 - 3.0	1.7 - 2.7	8 - 55	400 Myr - 3 Gyr
F	6,000 - 7,500	White-yellow	medium	weak ionised Ca <sup>+</sup>	1.1 - 1.6	1.2 - 1.6	2.0 - 6.5	3 - 7 Gyr
G	4,900 - 6,000	Yellow	weak	ionised Ca <sup>+</sup> , metal lines	0.85 - 1.1	0.85 - 1.1	0.66 - 1.5	7 - 15 Gyr
K	3,500 - 4,900	Orange	very weak	Ca <sup>+</sup> , Fe, strong molecules, CH, CN	0.65 - 0.85	0.65 - 0.85	0.10 - 0.42	17 Gyr
M	2,000 - 3,500	Red	very weak	molecular lines, eg TiO, neutral metals	0.08 - 0.05	0.17 - 0.63	0.001 - 0.08	56 Gyr
L?	<2,000	Tentative new (2000) classification for very low mass stars.			<0.08	May or may not be fusing H in cores?		



# Hertzsprung-Russell Diagram

22,000 stars from the Hipparcos Catalogue + 1,000 Low-lum.

# Orion



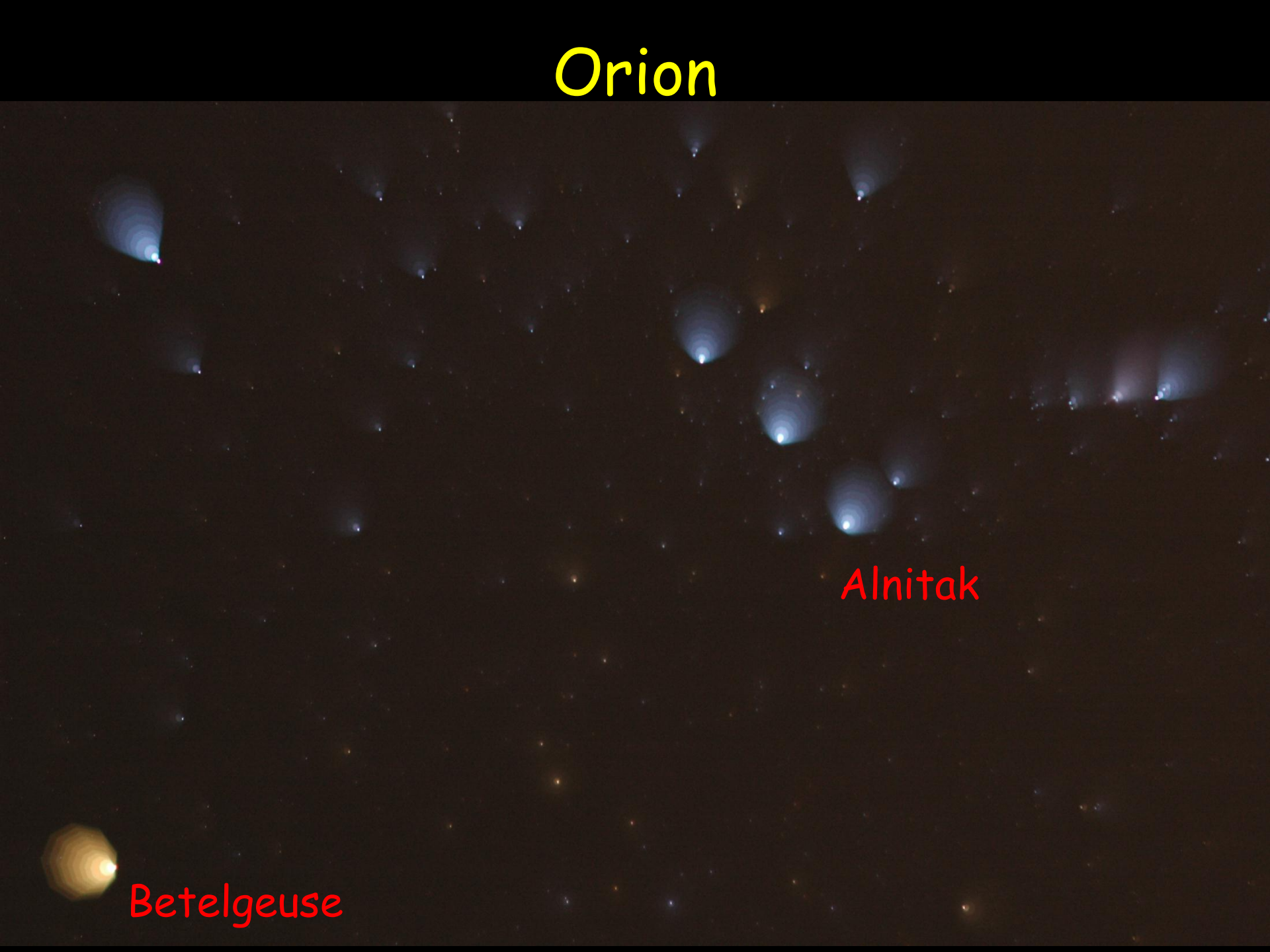
Betelgeuse

Alnitak

# Orion

Alnitak

Betelgeuse



# Star Analyzer 100 on DSLR

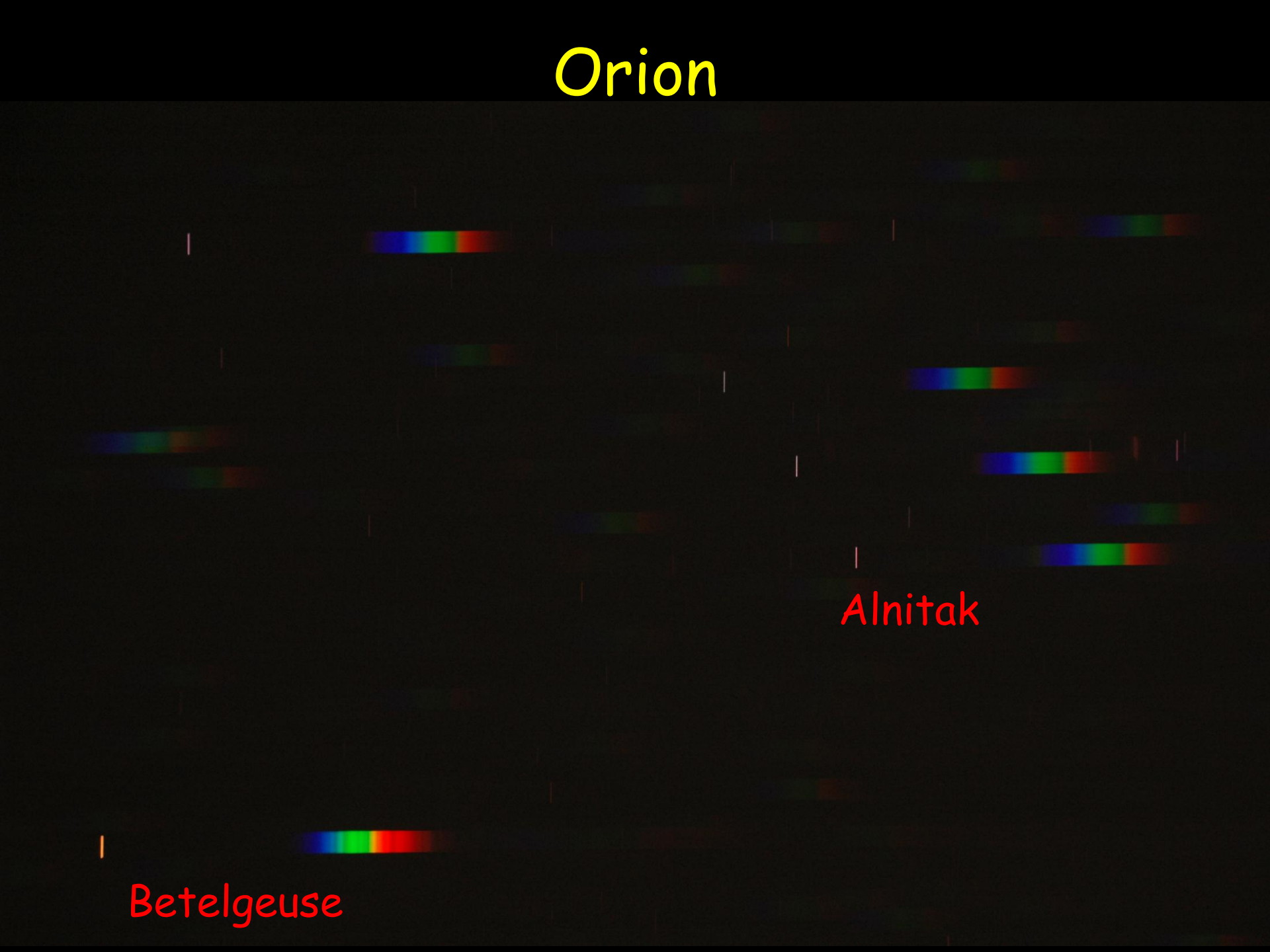
100 lines/mm blaze grating



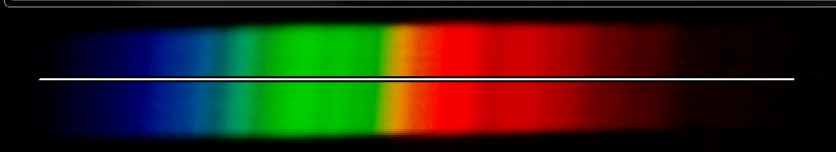
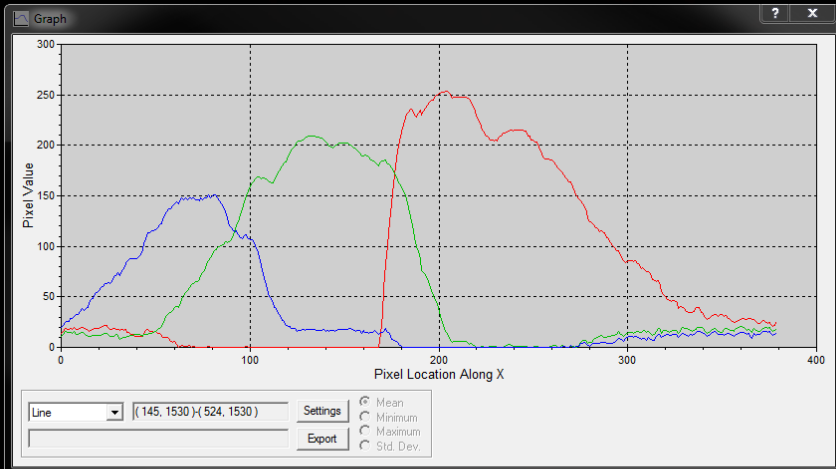
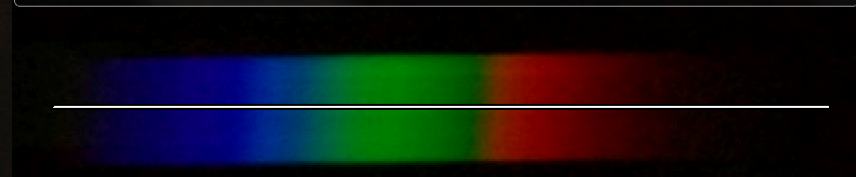
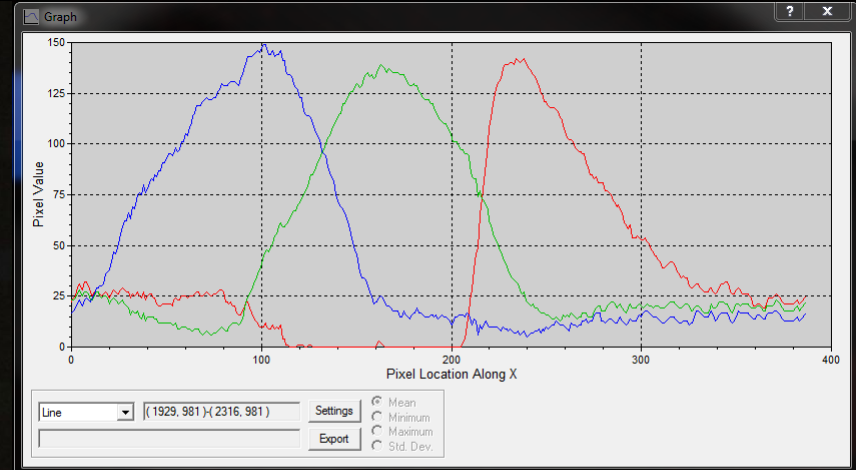
# Orion

Alnitak

Betelgeuse



# Orion

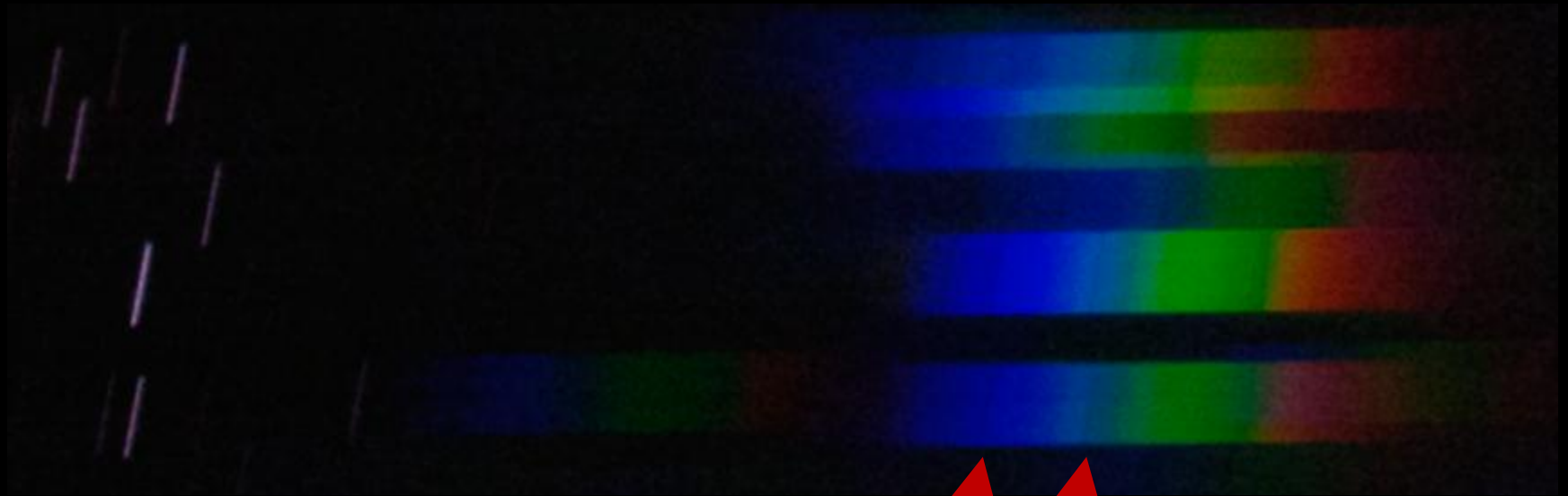


Alnitak O9.7Ib

Betelgeuse M2Iab

# Pleiades M45 Stars Spectrum

SA100 on Nikkor 85mm lens, 1 minute image

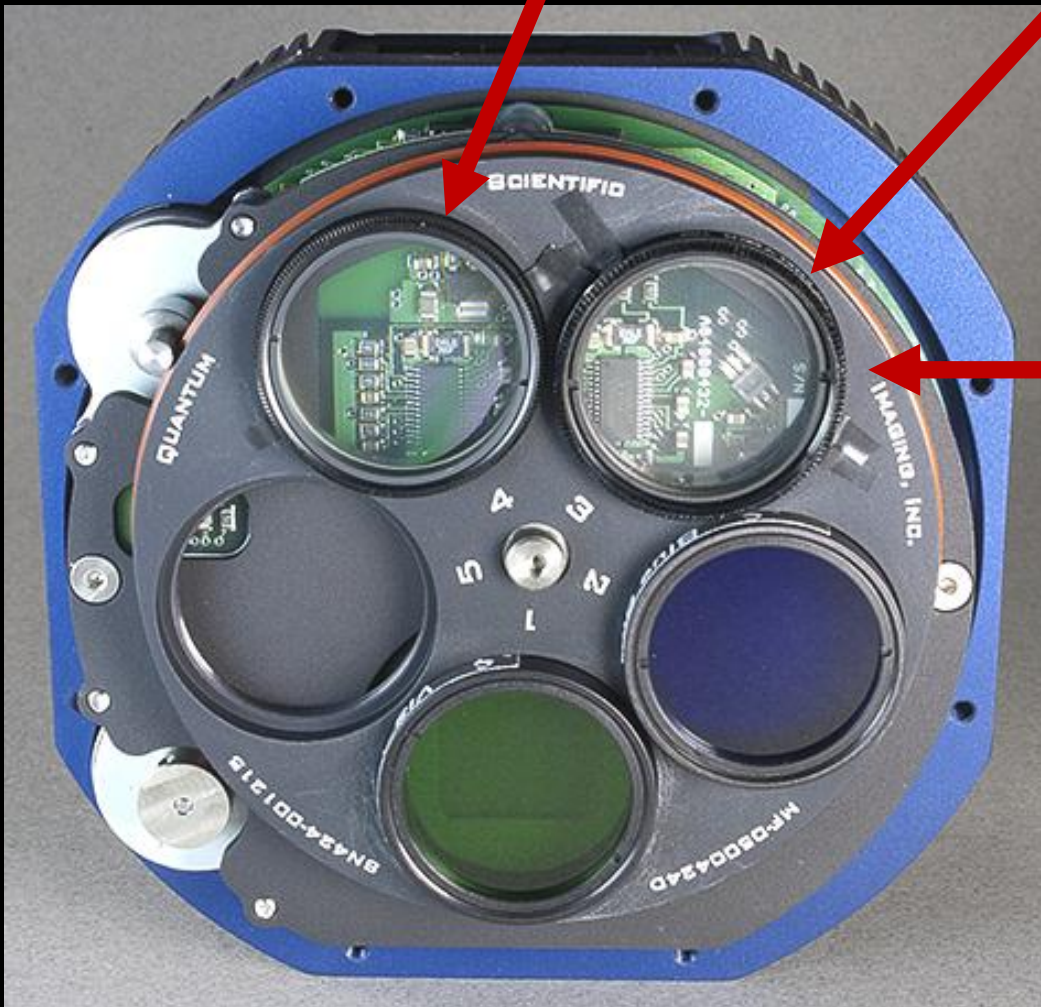


H $\gamma$  H $\beta$



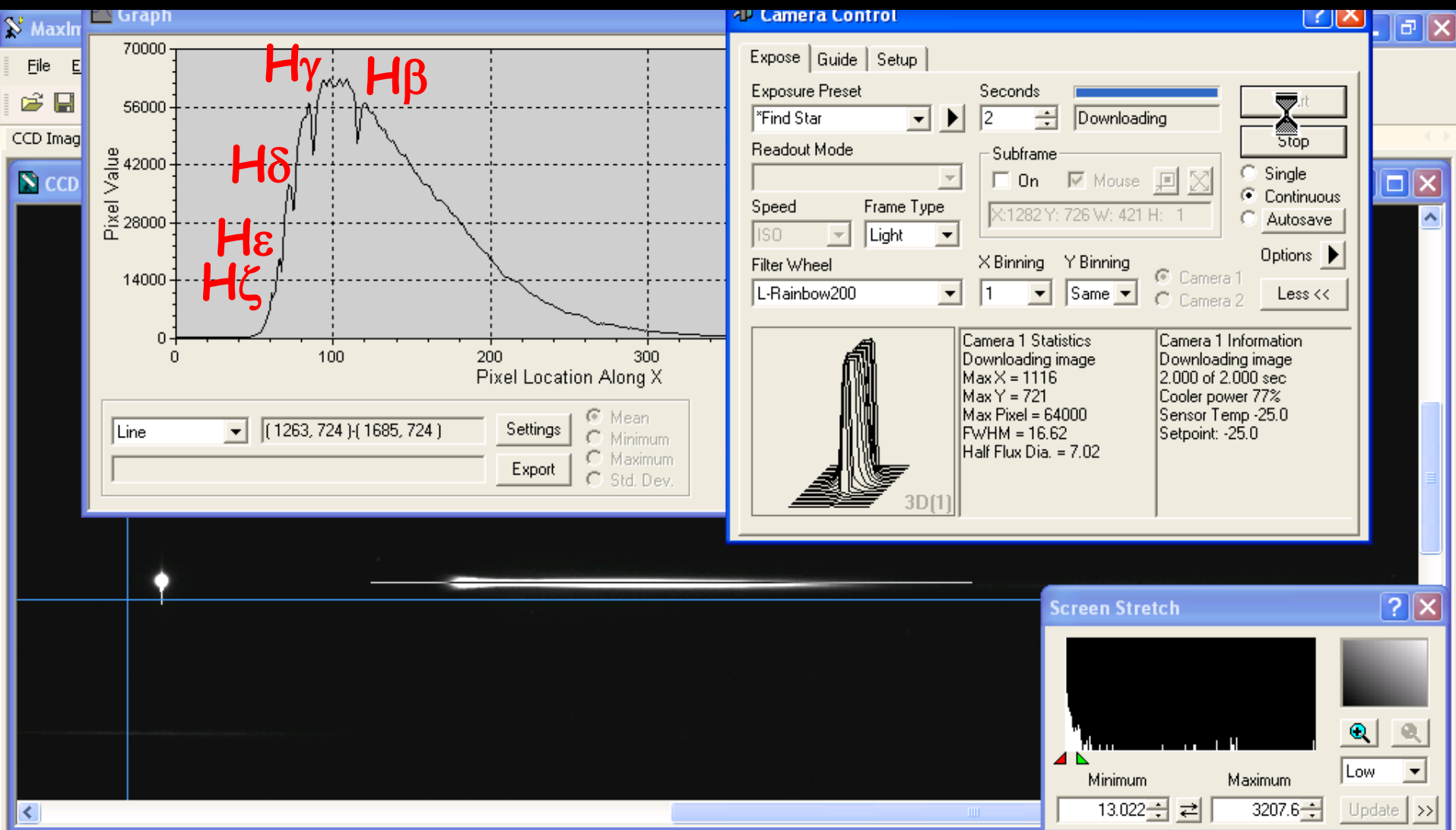
# 2 Gratings in QSI 532 Camera

Star Spectroscope 200 l/mm & Star Analyzer 100 (100 l/mm)



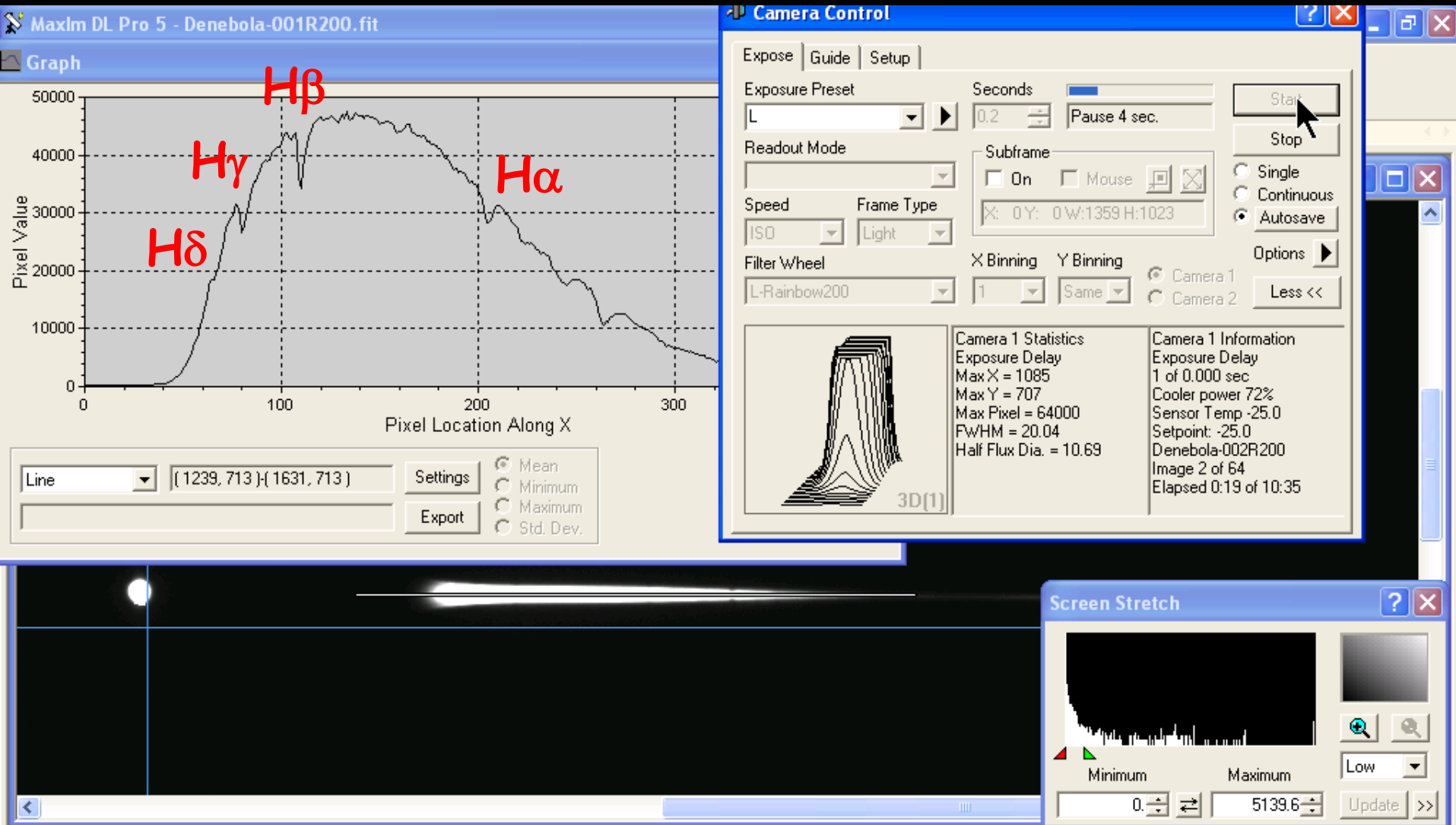
# Denebola A3Va Spectrum

## Star Spectroscopy in QSI532 & NP127is



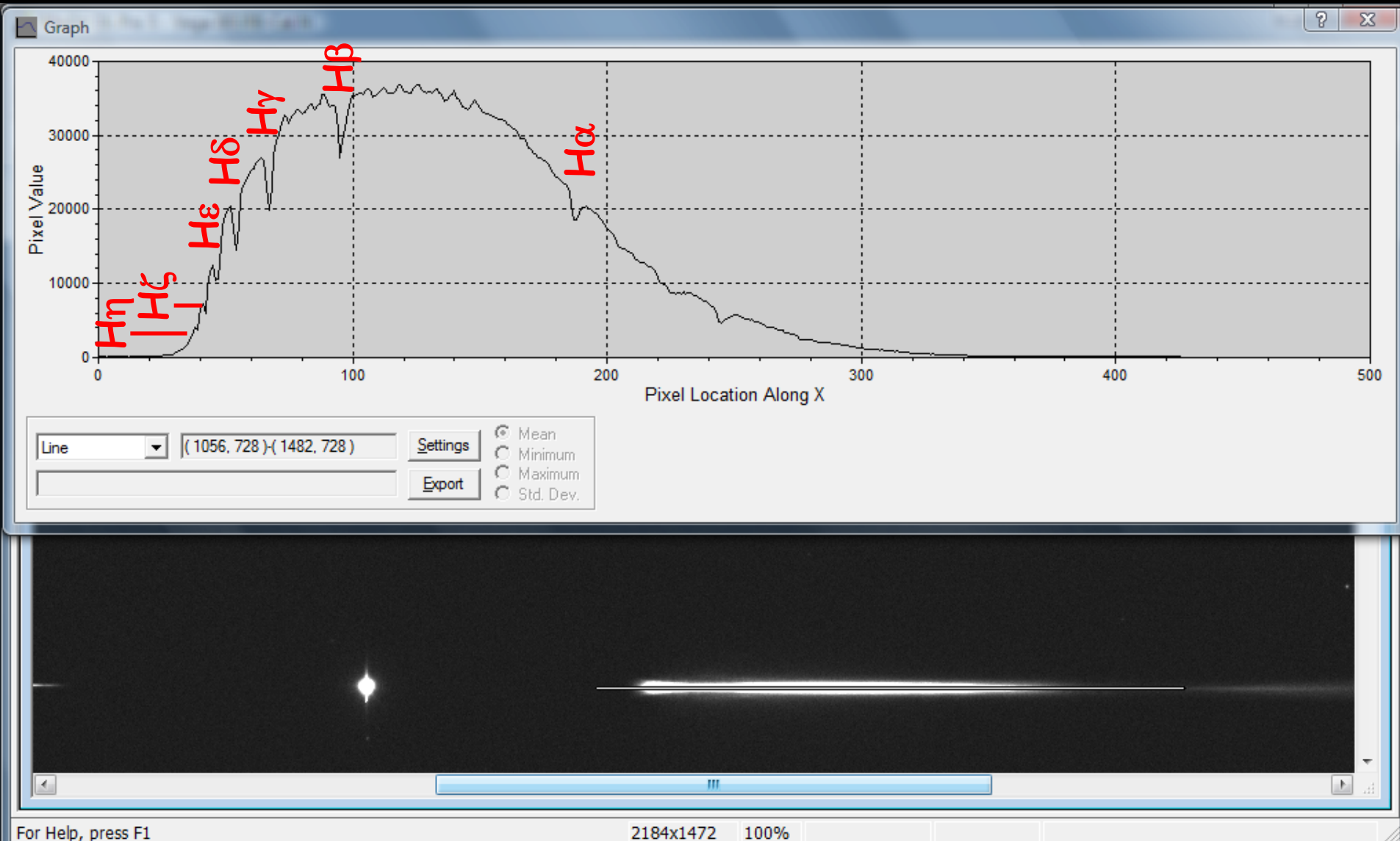
# Denebola A3Va Spectrum

## Star Spectroscope in QSI532 & NP127is



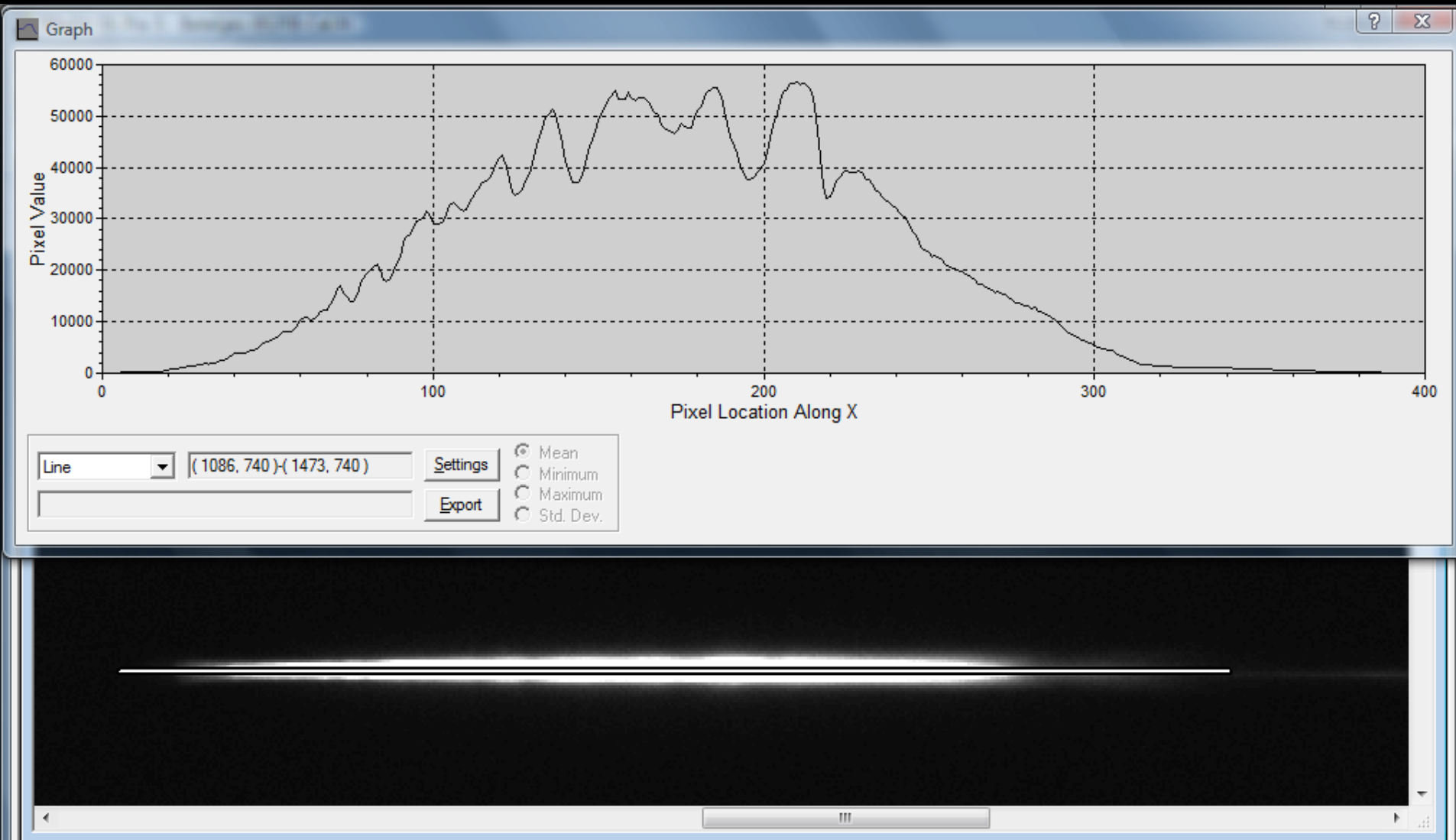
# Vega Spectrum AOV

Star Spectroscope in QSI532 & NP127is



# Betelgeuse M2Iab Spectrum

Star Spectroscope in QSI532 & NP127is

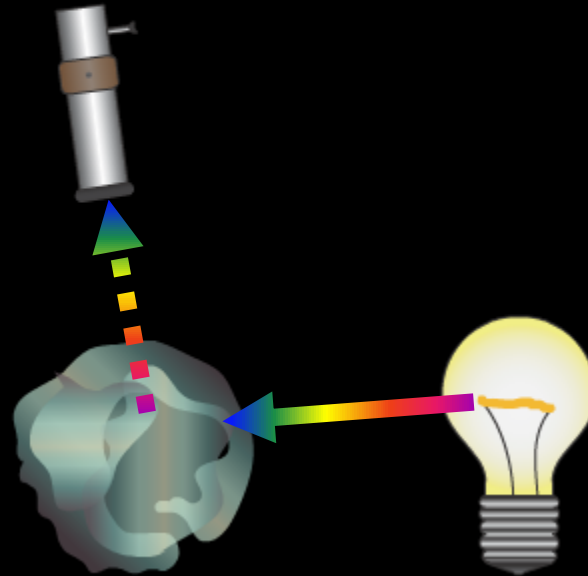


# Emission Spectrum

Kirchoff radiation emission law



Drag the telescope around to see how the three main types of spectra (continuous, absorption, and emission) are obtained from a cold, thin gas cloud and an incandescent lightbulb in space.

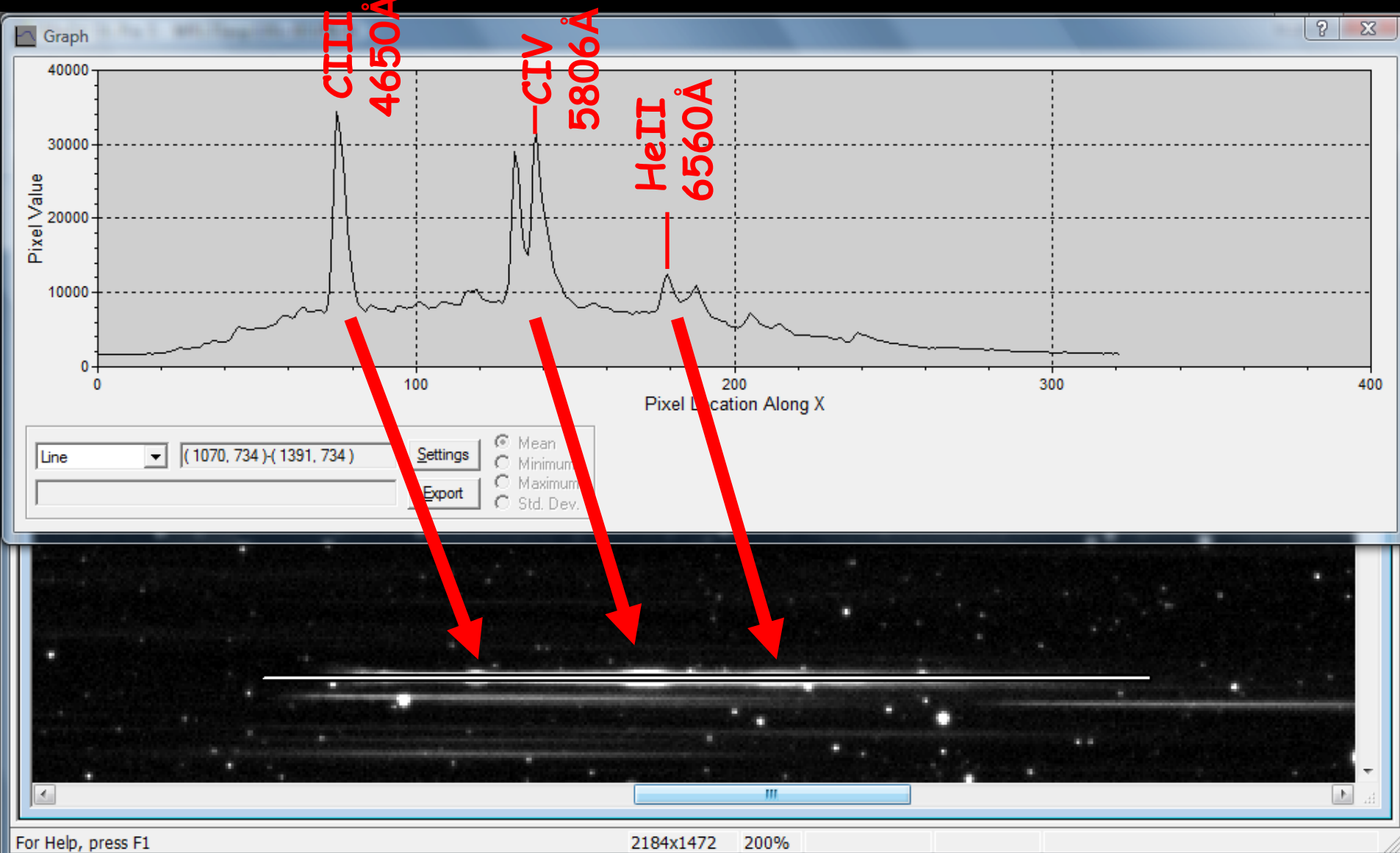


Star atmosphere,  
Nebula, etc.

Star

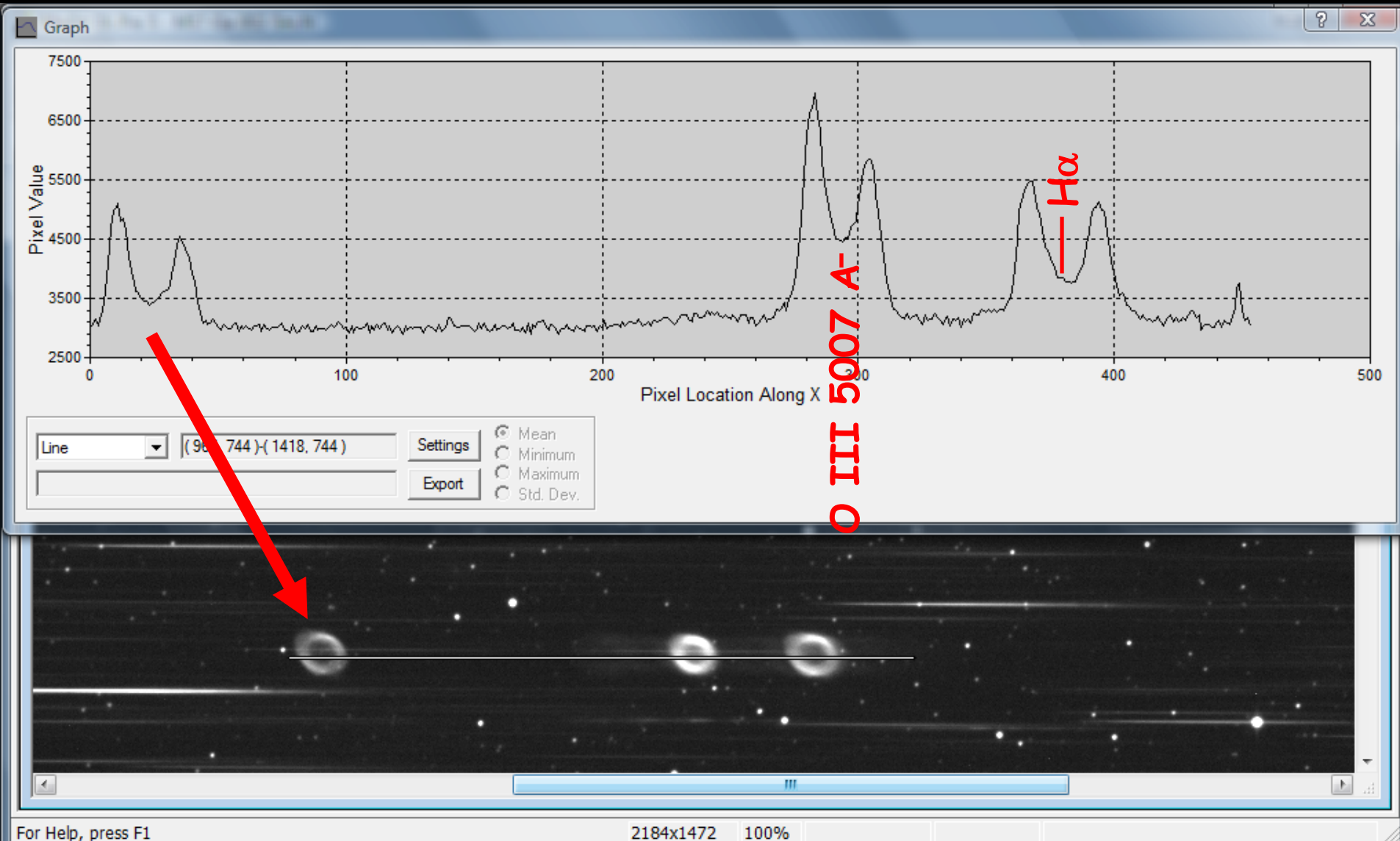
# Wolf-Rayet Star WR135 WC8 Spectrum

Star Spectroscope in QSI532 & NP127is



# M57 Spectrum

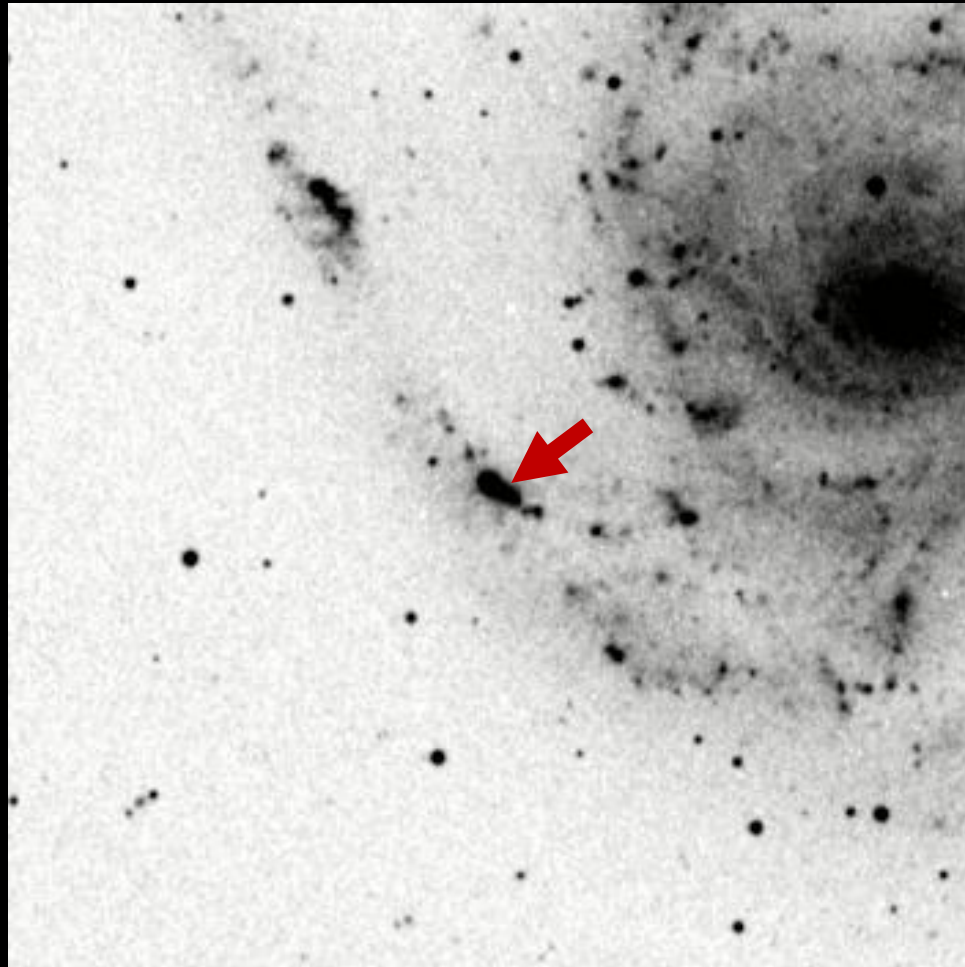
Star Spectroscope in QSI532 & NP127is





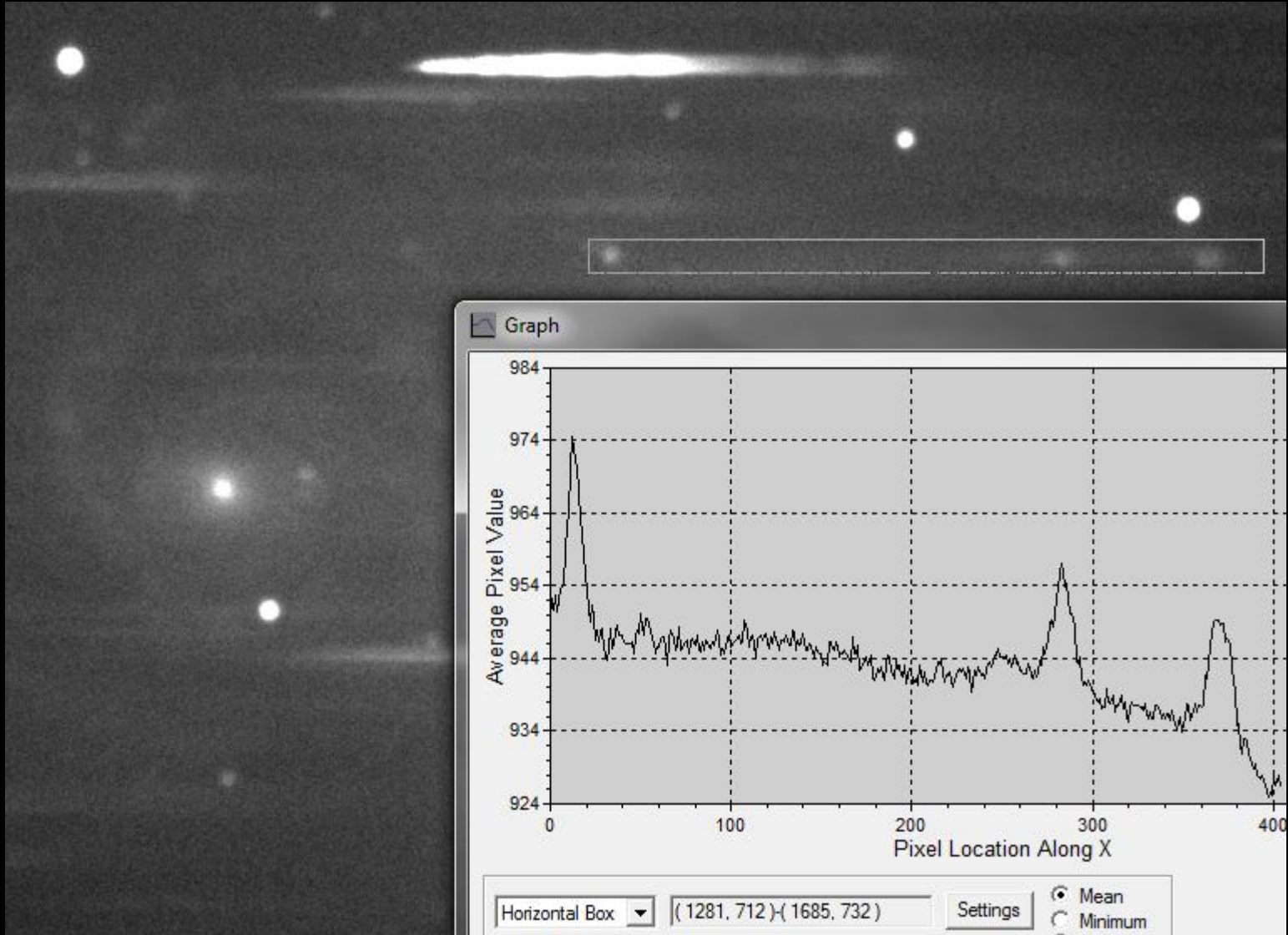
# M101 HII Region Spectrum

NGC 5461



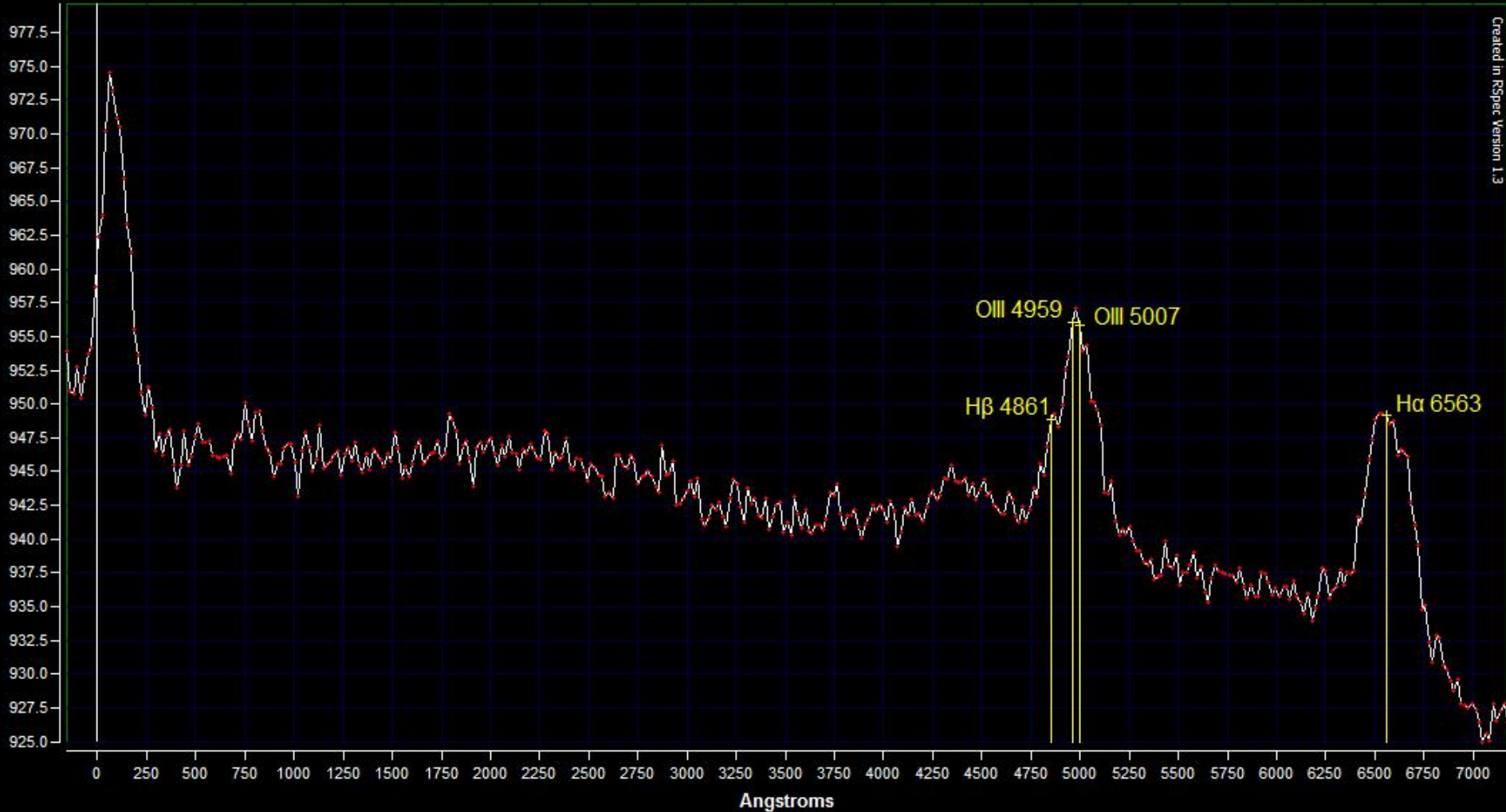
# NGC 5461 M101 HII Region Spectrum

Star Spectroscope in QSI532 & 150mm Maksutov-Cassegrain



# M101 HII Region Spectrum

NGC 5461



Created in RSpec Version 1.3

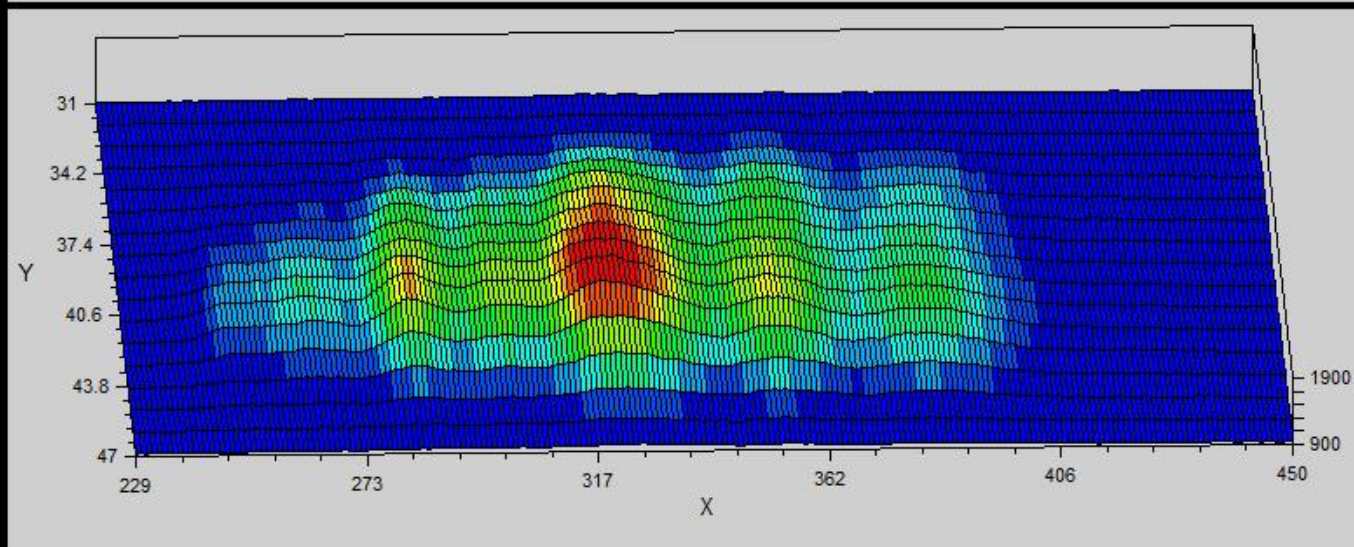
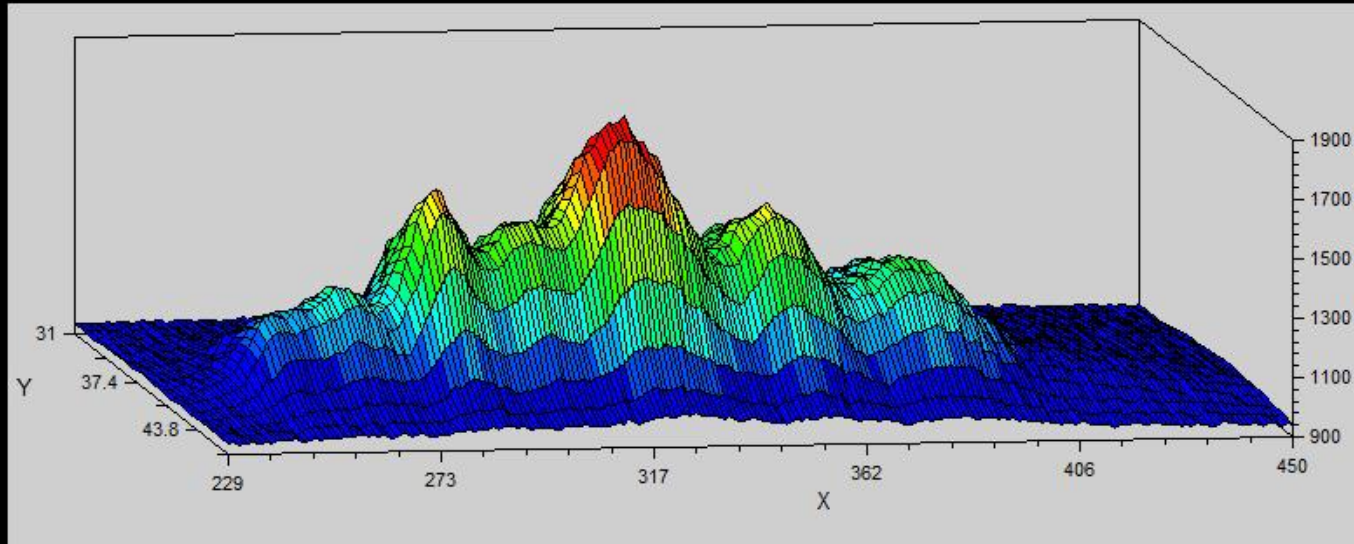
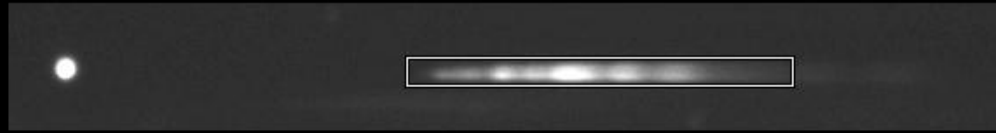
# Supernovae SN 2011fe Spectrum

M101 light travel-time = 16 Myr



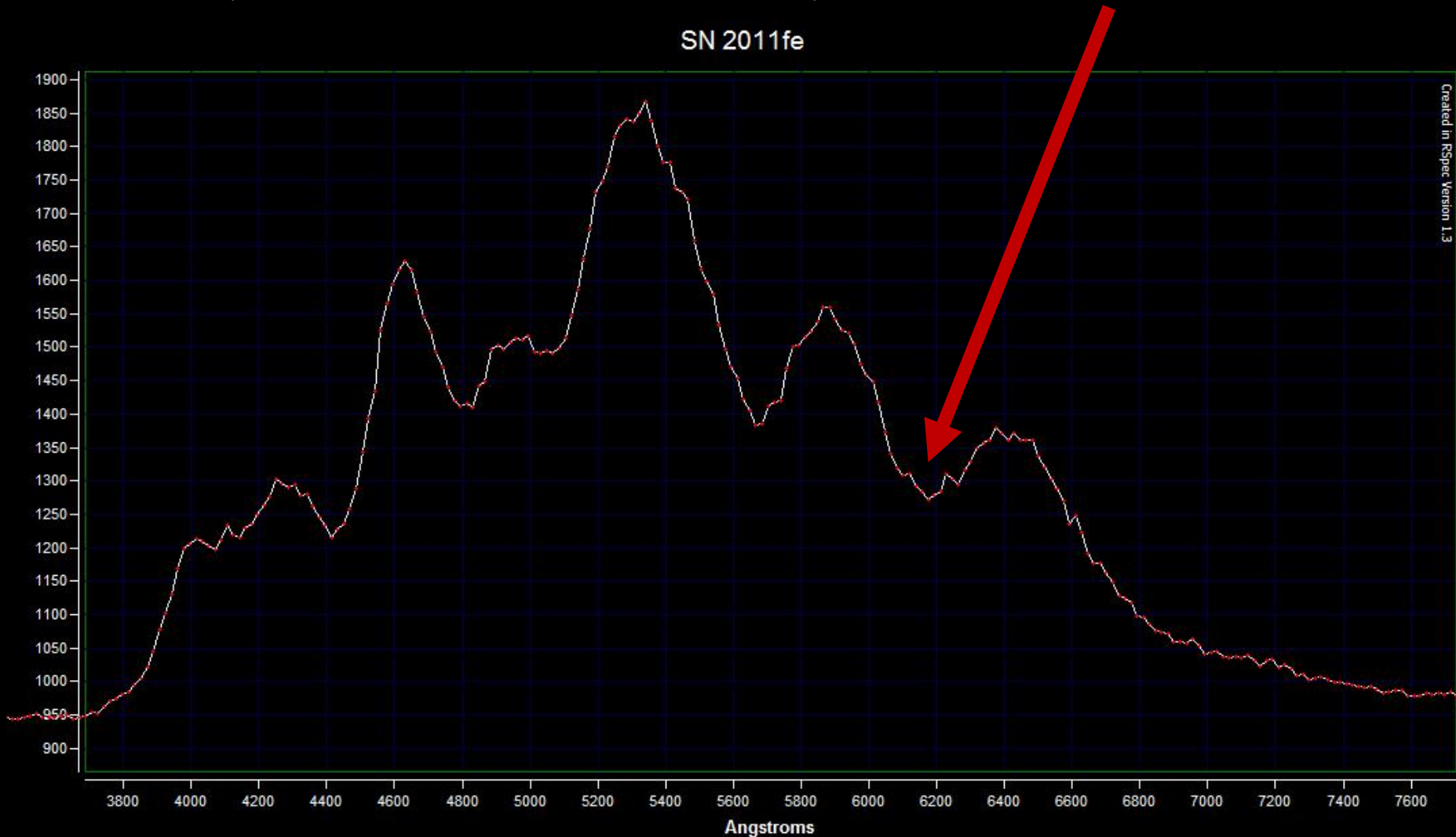
**SDSS Image**

# Supernovae SN 2011fe Spectrum

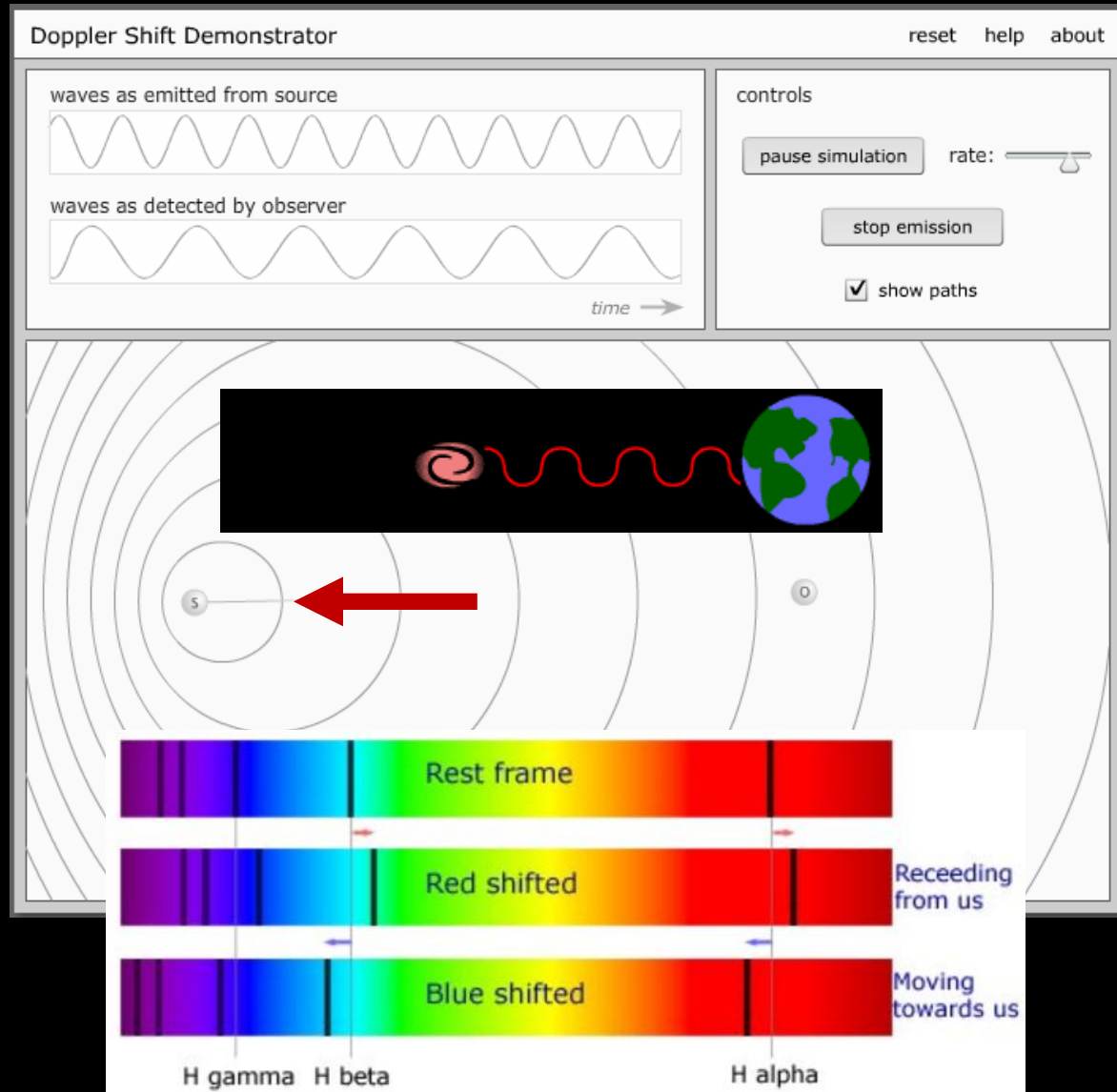


# Supernovae SN 2011fe Spectrum

Supernovae type Ia = absence of hydrogen lines & presence of a SiII absorption near 6150 Å.



# Radial Velocity Red & Blue Shift



Credit: Nebraska Astronomy Applet Project [astro.unl.edu](http://astro.unl.edu)

[http://outreach.atnf.csiro.au/education/senior/astrophysics/spectra\\_info.html](http://outreach.atnf.csiro.au/education/senior/astrophysics/spectra_info.html)

# Quasar 3C 273 Spectrum

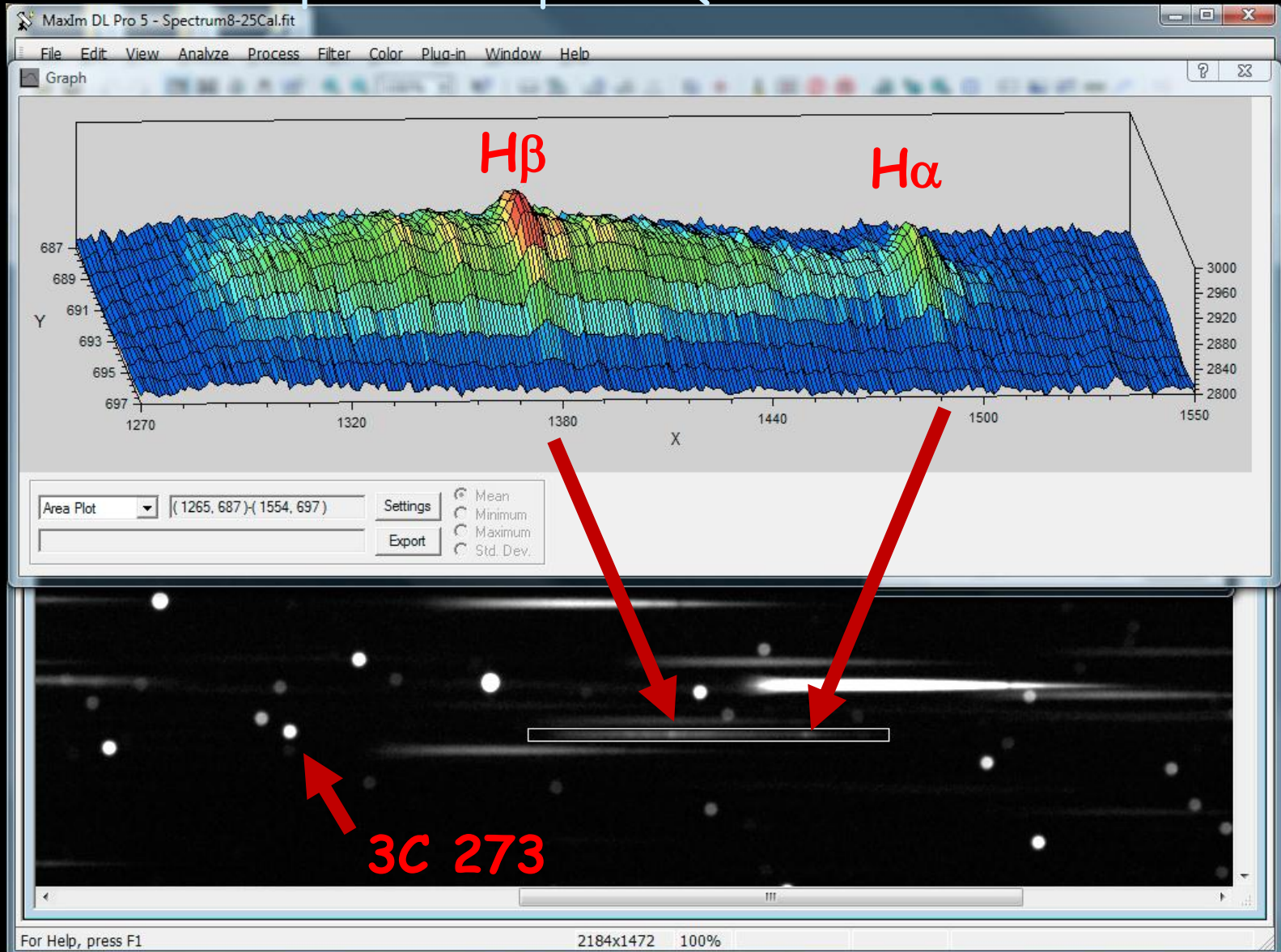
Redshift Measurement



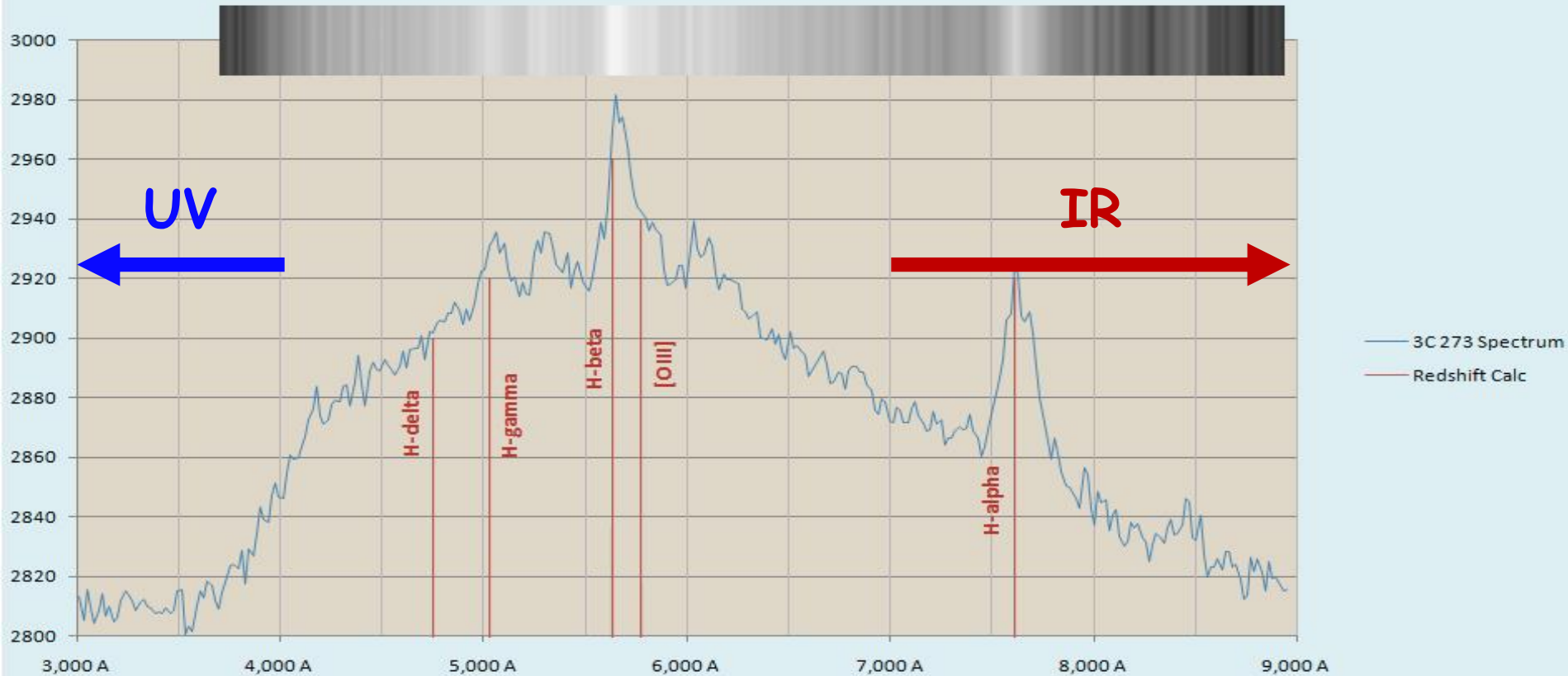


# Quasar 3C 273 Redshift

Star Spectroscope in QSI532 & NP127is



# Quasar 3C 273 0.158 Redshift



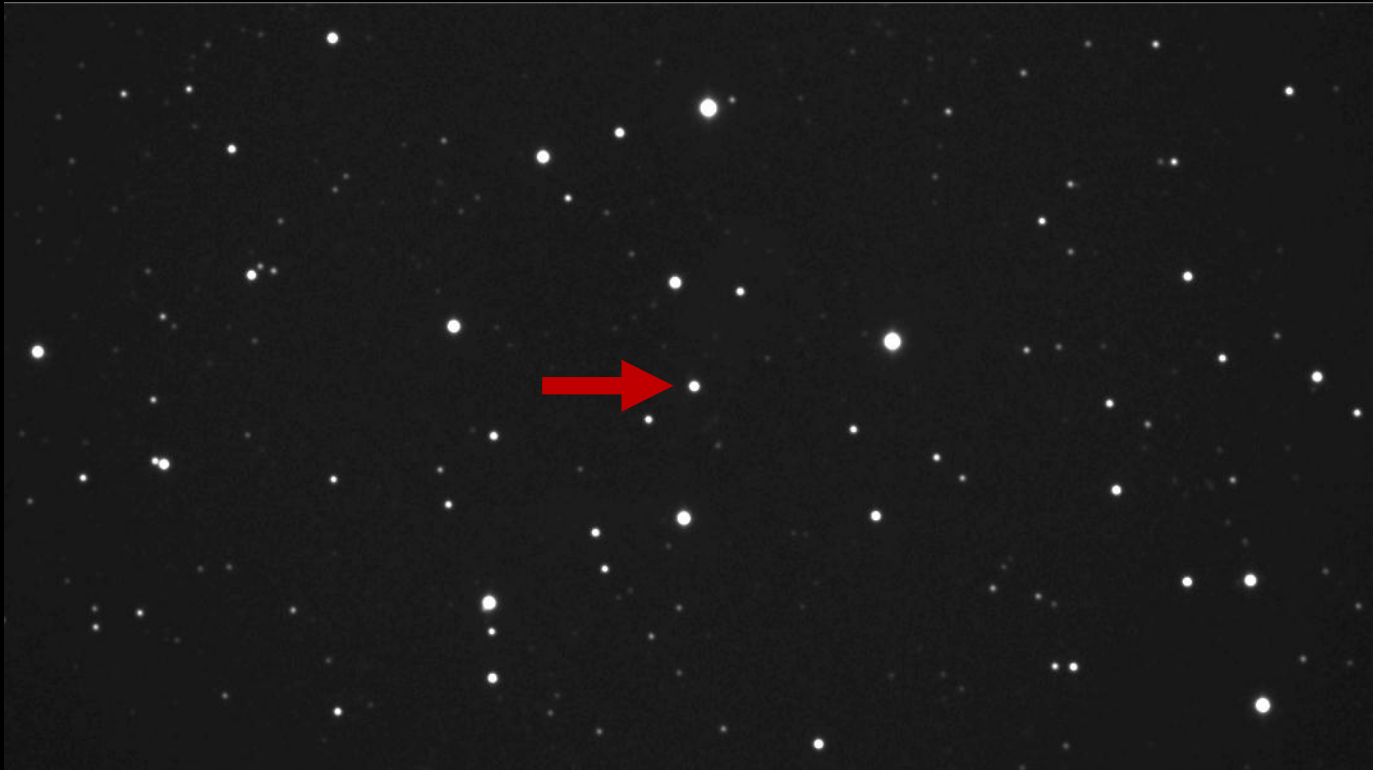
**3C 273 Redshift**  
 **$z=0.158339$**

$$z = \frac{\lambda_{\text{obsv}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}}$$

<u>Elements</u>	<u>Emit Wavelength</u>	<u>Redshift Change in Wavelength</u>	<u>Observed Wavelength</u>
H-alpha	6563 Å	1039 Å	7602 Å
[O III]	5007 Å	793 Å	5800 Å
H-beta	4861 Å	770 Å	5631 Å
H-gamma	4340 Å	687 Å	5027 Å
H-delta	4102 Å	650 Å	4752 Å

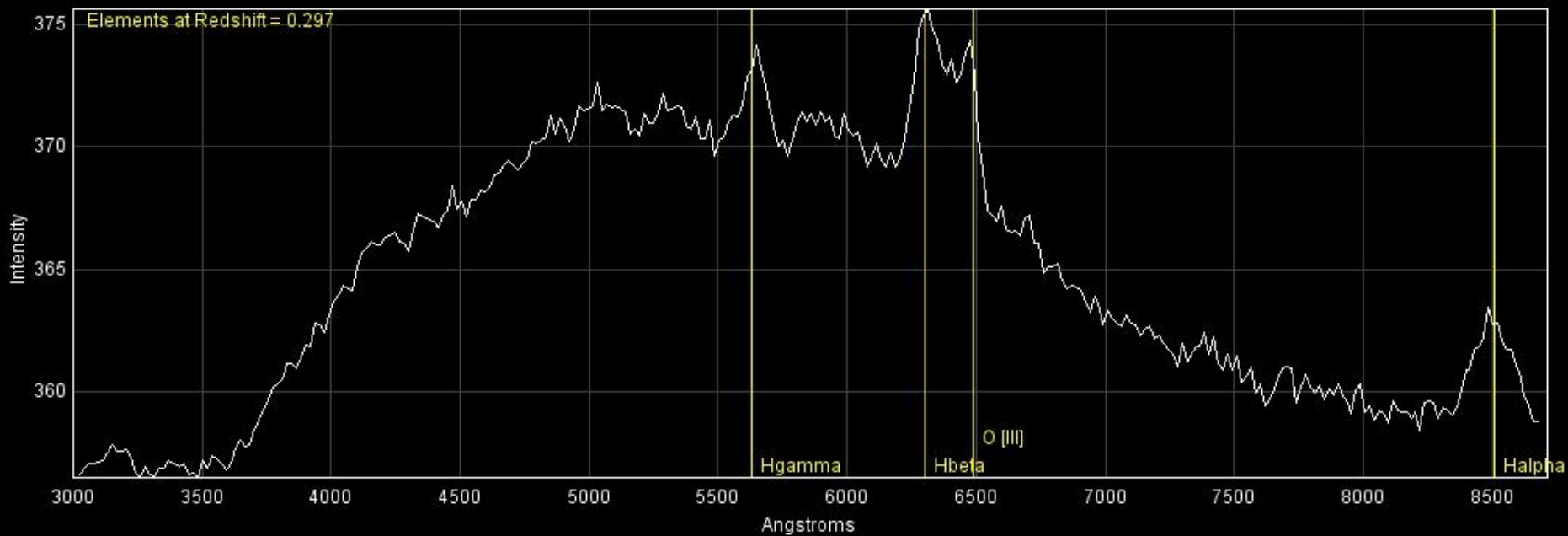
# Quasar KUV18217+6419 Spectrum

Redshift Measurement



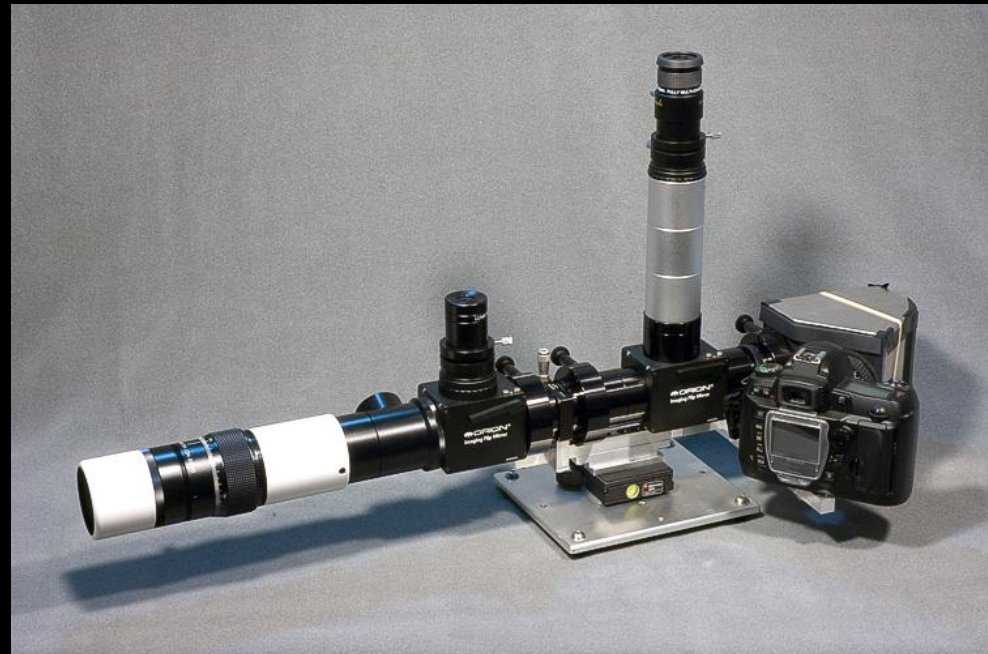
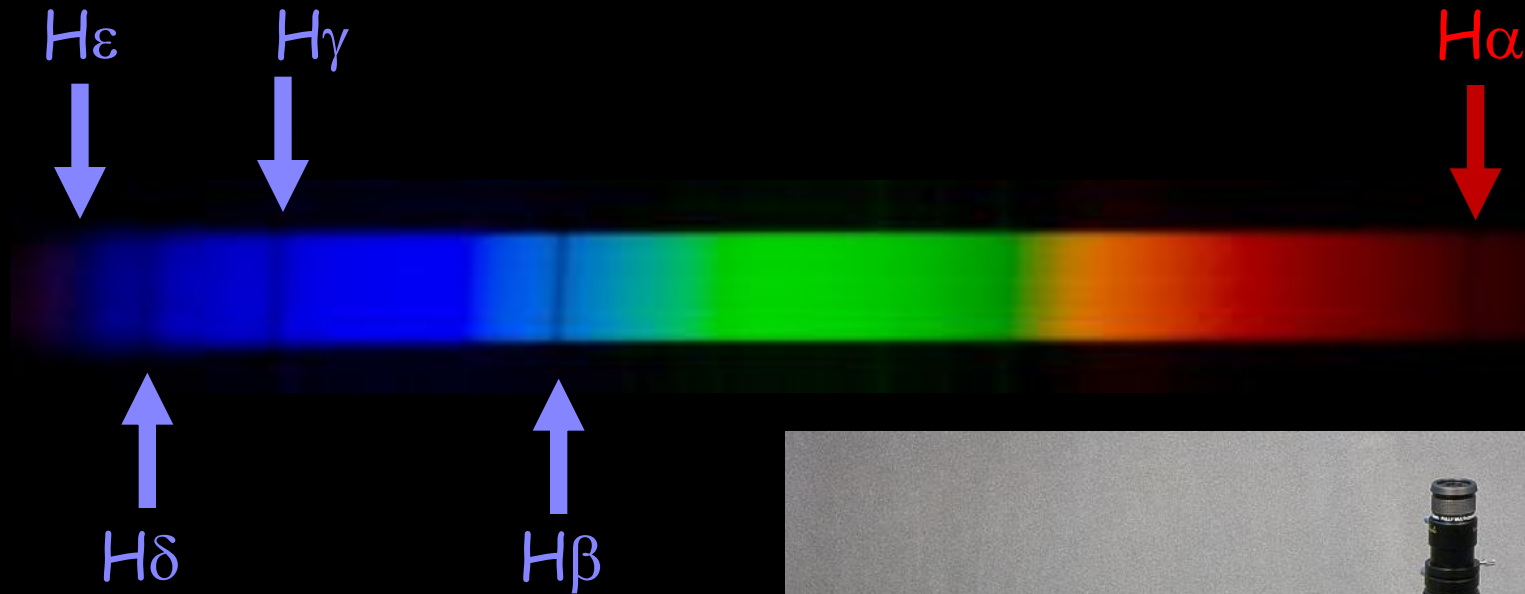
# Quasar KUV18217+6419 Redshift 0.296

Light travel time = 3.264 Gyr



# Vega Hydrogen Absorption Spectrum

600 lines/mm grating




<http://www.stargazing.net/david/spectroscopy/links.html>

Spectroscopy Links - Windows Internet Explorer  
http://www.stargazing.net/david/spectroscopy/links.html  
Light

Navigation: <<PREVIOUS - HOME - CONTENTS - NEXT>>  
SPECTROSCOPY INDEX - ~~NEW~~

## Astronomical Spectroscopy and Related that I Found Useful



- Astronomical Spectroscopy Associations, Communities, etc.**
  - [Astronomical Ring for Access to Spectroscopy](#)
    - [The SPECTRO Bookmarks](#)
    - [PRINCIPALES RAIES SPECTRALES OBSERVABLES DANS LES SPECTRES STELLAIRES ET DE NEBULEUSES PLANETAIRES](#)
    - [Identification of telluric lines](#)
  - [ASP - Active Spectroscopy in Astronomy](#)
  - [CAOS Amateur Astronomical Spectroscopy](#)
  - [Forum for Amateur AstroSpectroscopy](#)
  - [Spectroheliophone Network](#) Fredrick Veio and Chris Westland
  - [SAS: Society for Astronomical Sciences](#)
  - [Vds: Amateur Astronomy Association - Germany Section Spectroscopy](#)
- Amateur Astronomical Spectroscopy Websites and Web Pages**
  - Christian Buil: [Spectroscopy, CCD & Astronomy](#)
    - [UN STAGE DE SPECTROGRAPHIE ASTRONOMIQUE](#)
  - Dalé Mais: [Mais Observatory: CCD Spectroscopy](#)
    - [Amateur Astronomical Spectroscopy: Highlights of what is Currently Achievable](#)
  - John A. Blackwell: [Regulus! Astronomy Education: Spectroscopy](#)
  - Jose Ribeiro: [Amateur Astrophysics](#)
  - Ken Harrison:
    - [Classical Spectroscope](#)
    - [Spectroscopes: Part 2 - New 200mm Littrow design](#)
  - Dr. Lothar Schanne: [Spectrosphere](#)
- Astronomical Spectroscopy Hardware**
  - [Baader Planetarium](#) DADOS Spaltspektrographien
    - [DADOS user manual](#) PDF
  - [Paton Hawksley Education LTD](#) Star Analyzer 100
    - [ESPECTROSCOPIA CCD PRIMERAS EXPERIENCIAS](#) PDF
  - [Rainbow Optics](#) Star Spectroscopes
    - [Star Spectroscope manual](#) PDF
  - [Rigel Systems](#) RS-Spectroscope
    - [RS-Spectroscope manual](#) PDF
    - [RS-Spectroscope presentation](#) PDF
  - [SBIG](#) DSS-7 and SGS Spectrograph
    - [DSS-7](#) PDF
    - [SGS](#) PDF
  - [Shelyak Instruments](#) Lhires III, eShel Spectrograph, etc.
    - [Lhires III manual](#) PDF
    - [Lhires III CCD camera adapter](#) PDF
    - [Sepctrographe Echelle: un nouveau pas..., RCE Nov 20](#)
    - [Very good overview of books](#)
- Spectroscopy Hardware Parts**
  - [Edmund Optics](#)
  - [Newport](#)
  - [Surplus Shed](#)

www.stargazing.net/david


Observational Astronomy - Windows Internet Explorer

http://www.stargazing.net/david/ Yahoo! Search

Observational Astronomy

<<PREVIOUS - HOME - [CONTENTS](#) - NEXT>> - **NEW!**

# Observational Astronomy



David Haworth

The image shows a screenshot of a web browser displaying a website. The browser window has a title bar that reads "Observational Astronomy - Windows Internet Explorer". The address bar shows the URL "http://www.stargazing.net/david/". The page content features a dark, starry background with several galaxies and a comet. At the top, there are navigation links: "<<PREVIOUS - HOME - CONTENTS - NEXT>> - NEW!". The main title "Observational Astronomy" is centered in a large, bold, white font. Below the title, there is a small image of a person in a red jacket using a telescope. At the bottom of the page, the name "David Haworth" is written in a white font. The browser's toolbar includes icons for home, search, print, and other functions.