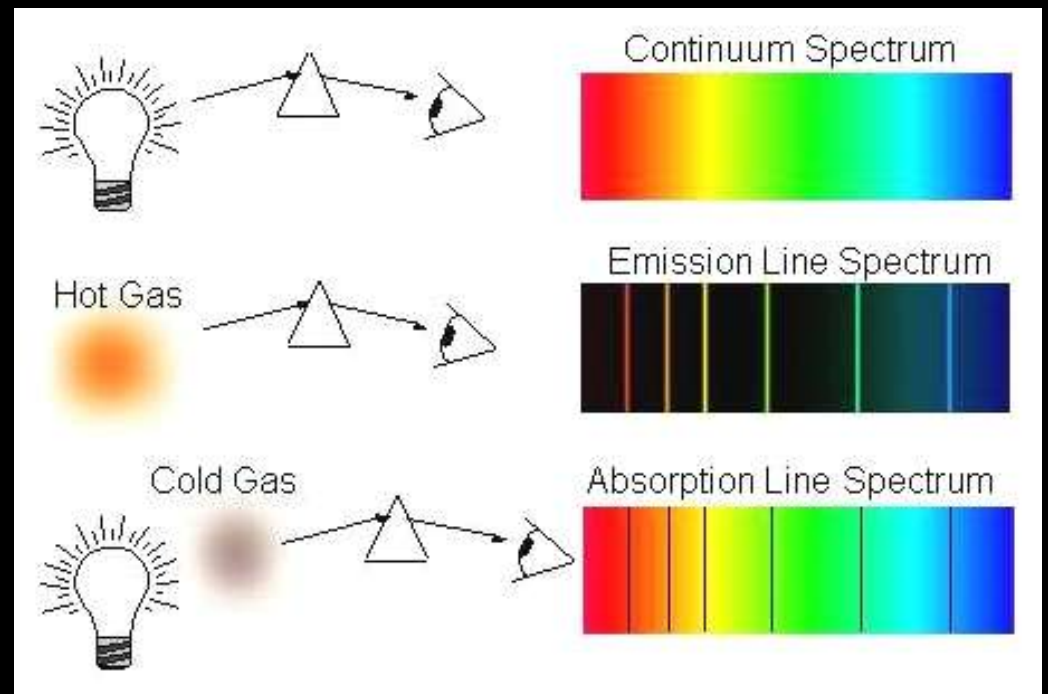


In 1835, Auguste Comte, famous French Philosophe, wrote in his Cours de la Philosophie Positive



*“On the subject of stars, all investigations which are not ultimately reducible to simple visual observations are ... necessarily denied to us. While we can conceive of the possibility of determining their shapes, their sizes, and their motions, **we shall never be able by any means to study their chemical composition or their mineralogical structure** ... Our knowledge concerning their gaseous envelopes is necessarily limited to their existence, size ... and refractive power, we shall not at all be able to determine their chemical composition or even their density... I regard any notion concerning the true mean temperature of the various stars as forever denied to us.”*

14 years later, Gustav Kirchhoff discovered that the chemical composition of a gas could be deduced from its spectrum



# And Stellar Spectroscopy Was Born!

- What do we learn about physics of stars from the spectra of Stars?



Temperature



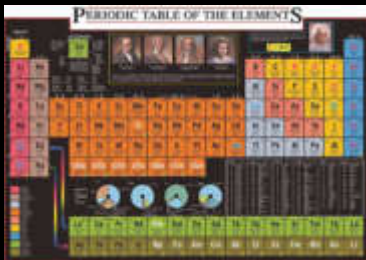
Pressure



Luminosity



Magnetic Fields



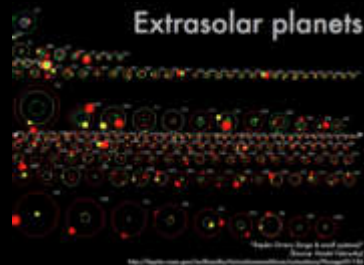
Chemical Composition



Motion through space



Rotation



Companion stars or planets

**And much, much more!**

# RS-Spectroscope



## Decoding the Message In Starlight

The RS-Spectroscope attaches to an eyepiece to spread light from stars and nebulae into a **rainbow** of colors – colors that provide a whole new way to enjoy astronomy.

# For Visual or Photographic Use

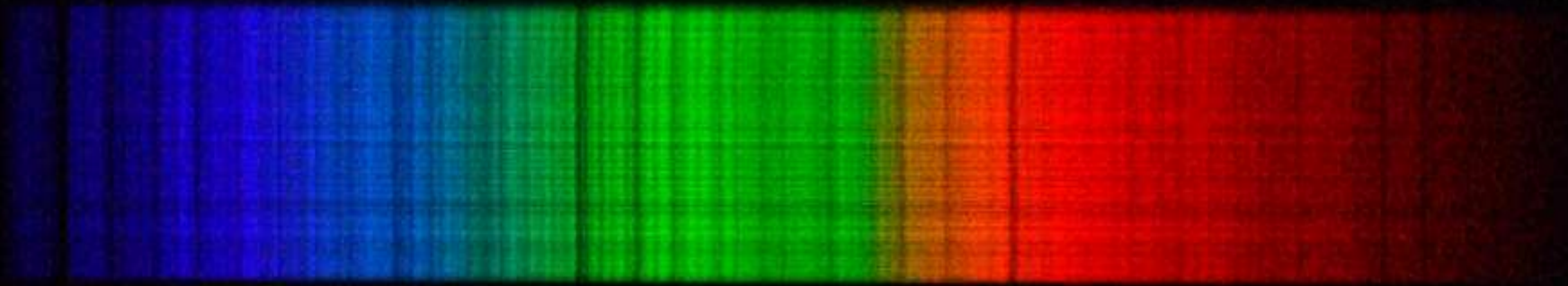
- This talk is about what you can do photographically with a Digital Camera



– Like the Canon EOS Rebel xti DSLR

# The Quick Answer...

- Something Like This!



– The Spectrum of Arcturus

# Mounting the Digital SLR

- QuikAdapt with extension





# The “Stack”

- Eyepiece collimates starlight
- **RS**-Spectroscope separates the colors
- Camera images spectrum





# Focus

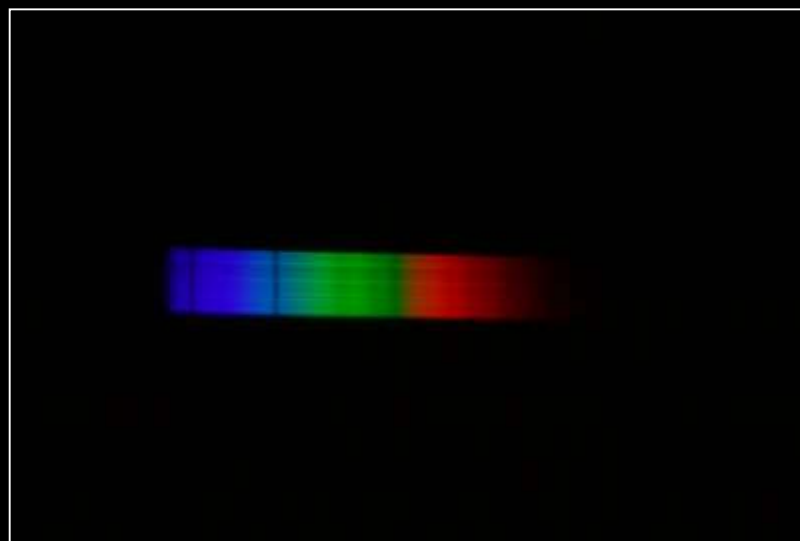
- Pick a bright star and focus spectrum to thin, crisp line in the viewfinder.



- Be sure
  - Camera is on manual focus
  - Camera is focused to infinity
  - Viewfinder diopter is neutral
  - Your glasses are on
- Take a few test exposures to check focus
  - Adjust focus either side of initial position to check

# Alignment

- Rotate *camera* to adjust spectrum parallel to long axis of image
- Take a *drift* spectrum and rotate *stack* so lines are nearly at right angles to spectrum



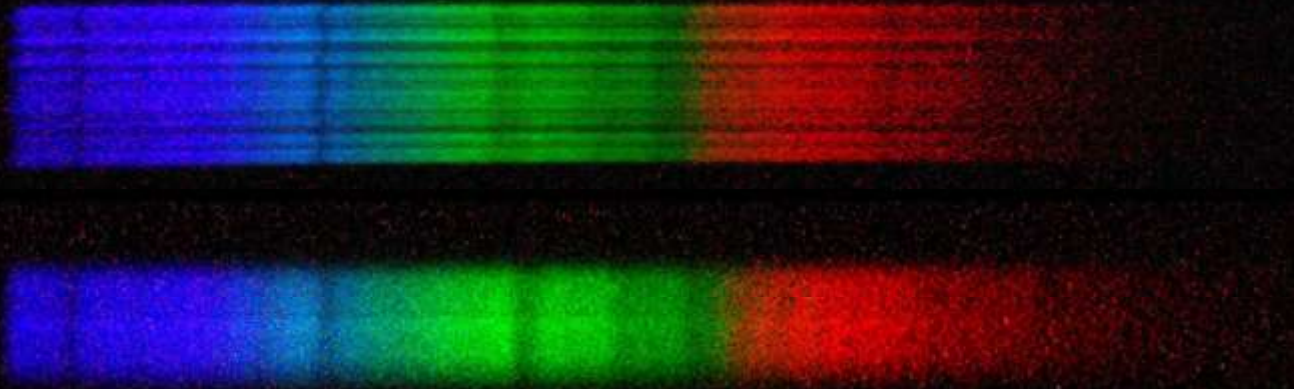
- Repeat until happy
- Fix any residual rotation and skew in Photoshop

# Exposure

- The quality of the spectrum depends on the magnitude of the star and these parameters you can adjust
  1. Camera focal length (70 is good)
  2. Camera F ratio (set to 5.0 and leave it there)
  3. Image quality (use L+RAW)
  4. Exposure time (up to 30 seconds)
  5. iso (100, 200, 400, 800, 1600)
  6. Telescope F ratio (huh?)

# Telescope F ratio (huh?)

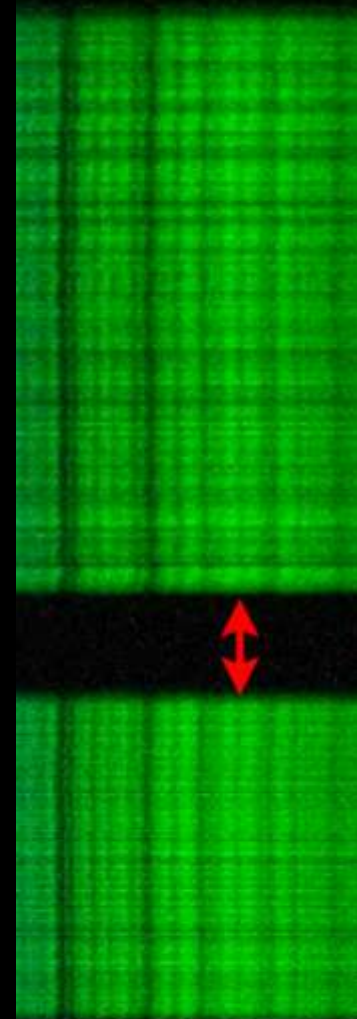
- The smaller the star image, the sharper the spectral lines
  - Here's Spica on a "steady" night



- And on a "windy" night
- Even on a "steady" night there's a lot of wiggle

# Telecompressor to the Rescue!

- Reduces the effective F-ratio of the telescope
- No telecompressor compared to telecompressor with  $M = 0.5$ 
  - Lines are sharper
  - Lines are less wiggly
  - System is *faster*



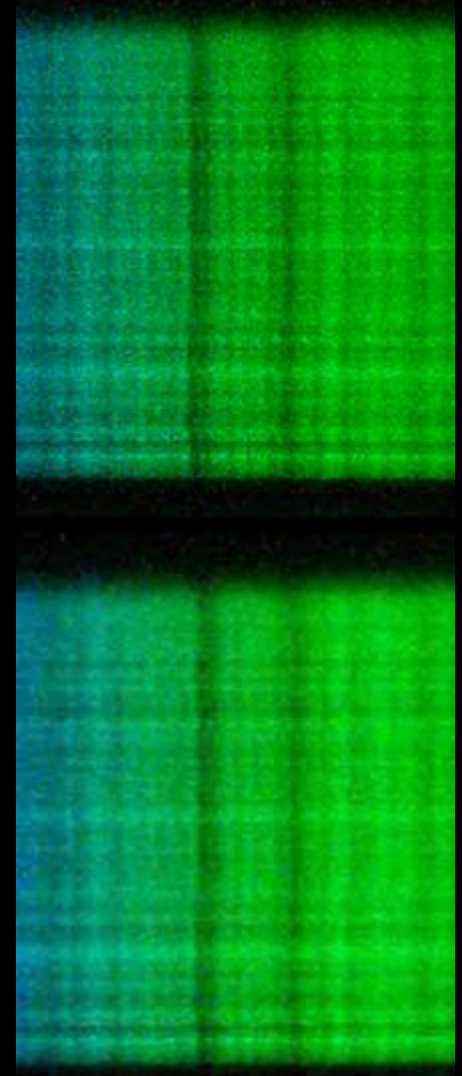
Arcturus

# Image Quality (use L+Raw)

- JPEG is *half* as sharp as TIFF
  - Canon utility will batch convert raw to TIFF

TIFF

JPEG



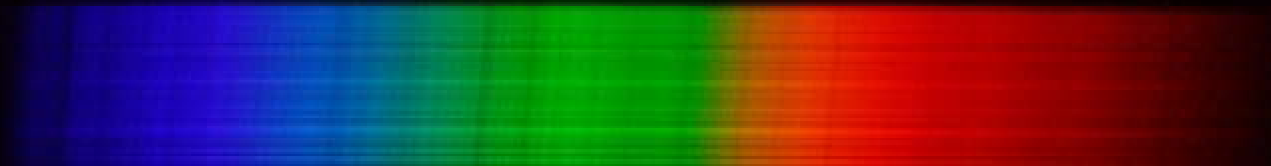
# Processing

1. Digital Photo Professional (comes with camera)
  - Convert RAW images from CR2 format to 8-bit TIFF
2. Photoshop (expensive)
  - Rotating, cropping & skewing
  - Generate spectrum continuum image
3. ImageJ (freeware)
  - Scale spectrum continuum
  - Subtract from the cropped/rotated/skewed spectrum image to enhance the spectral lines.
4. Photoshop (one more time)
  - Tweak the contrast



# Processing Example (Arcturus)

Raw Spectrum



Cropped, Rotated, De-skewed



Continuum



Continuum Subtracted

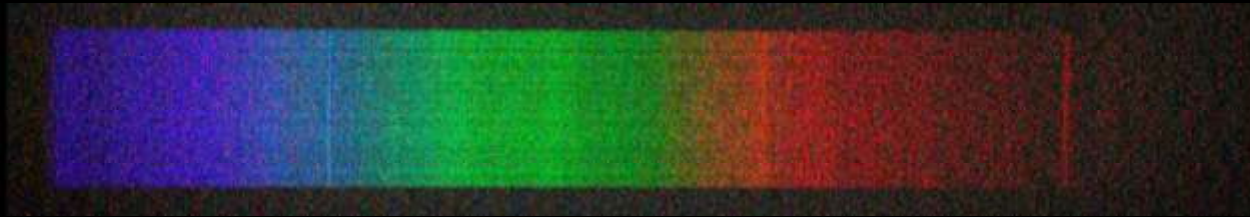


Auto Contrast

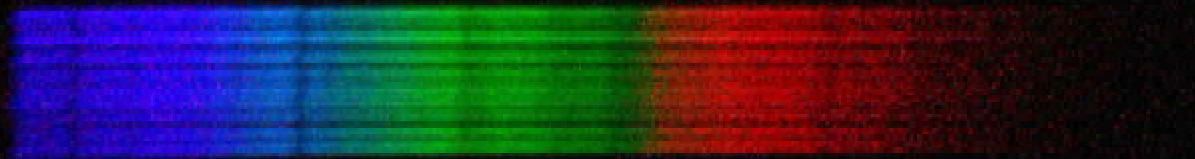


# More *Drift* Spectra

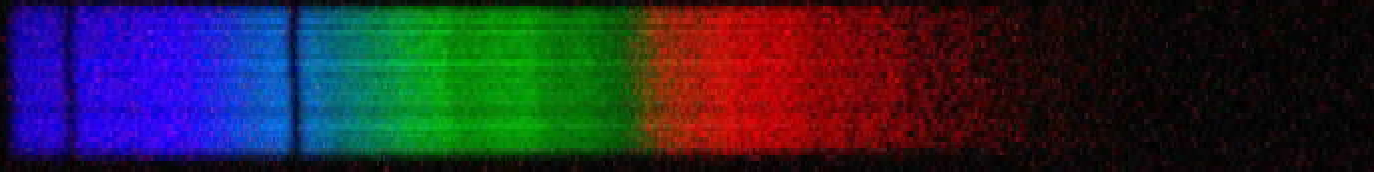
Delta Sco  
B0.3IV



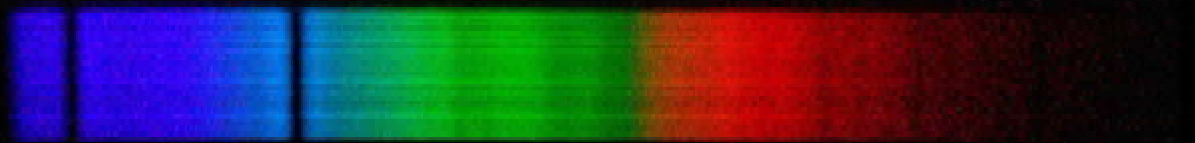
Spica  
B1 III-IV



Regulus  
B7V



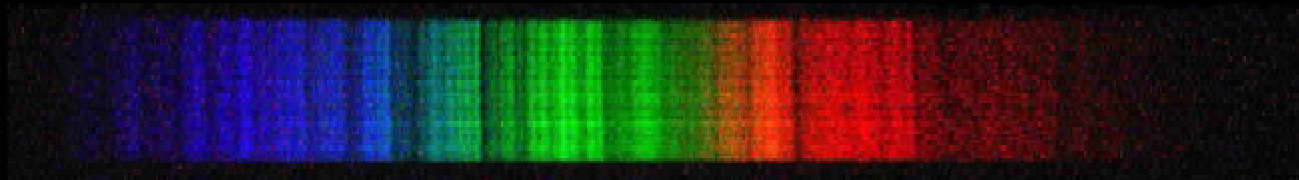
Vega  
A0V



Deneb  
A2 Ia



Antares  
M1.5 Iab



# Other Kinds of Spectra

*Streak Spectrum*  
before processing

after processing, some real and some not-so-real lines



*Nebular Spectrum*

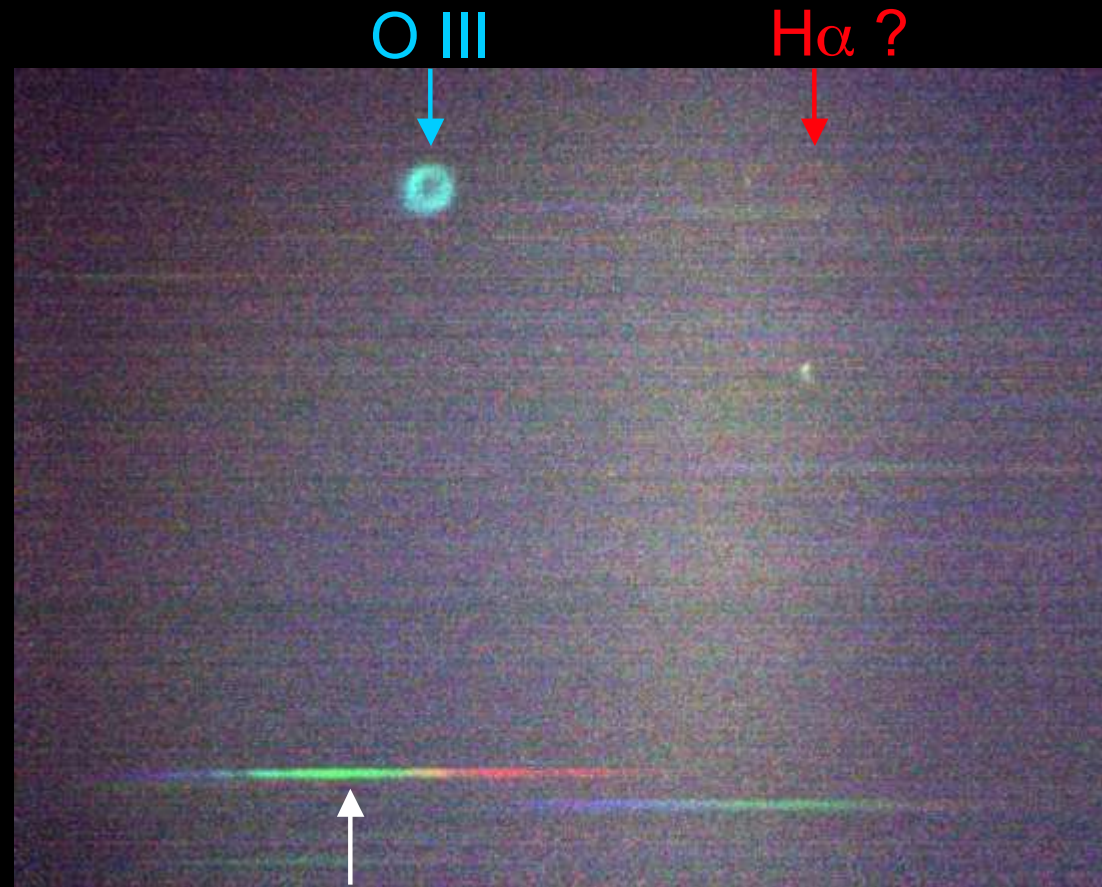
9th magnitude M57, 30 sec, moonlit night, a work in progress



# Nebular Spectrum

9th magnitude M57, a work progressing!

*Stack of eight 30 second exposures on a pretty good night for PV*



Spectrum of HD 175577, 8.7 mag, M spectral type



# RS-Spectroscope



A whole new way to enjoy astronomy

