AY257 Winter 2019
HMWK5 Example (IRAF)

- Load up IRAF from Anaconda

or using these instructions:

- Colorado College IRAF install

- Worked for three recent installs, remember for each session you have to activate iraf27 from your shell:

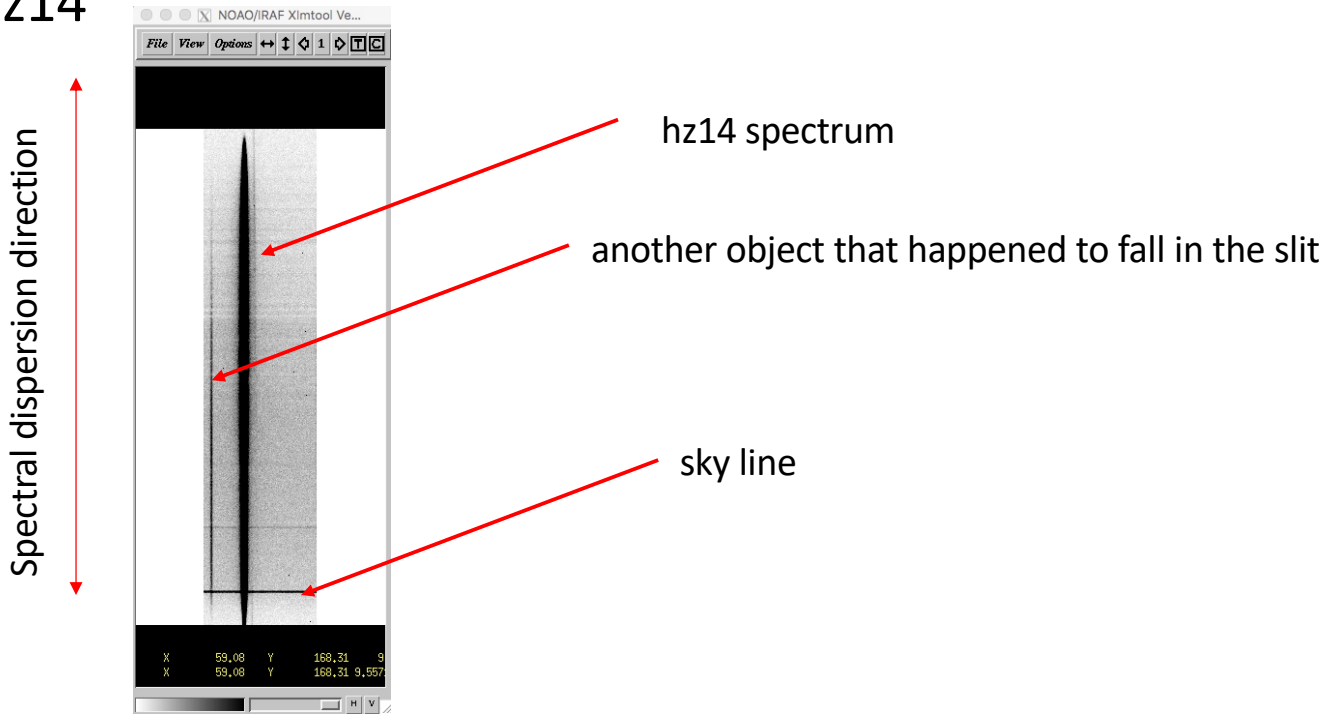
source activate iraf27

Start IRAF, go to directory with fits files, load *noao, twodspec, apextract*

Find Apertures, trace and extract spectrum

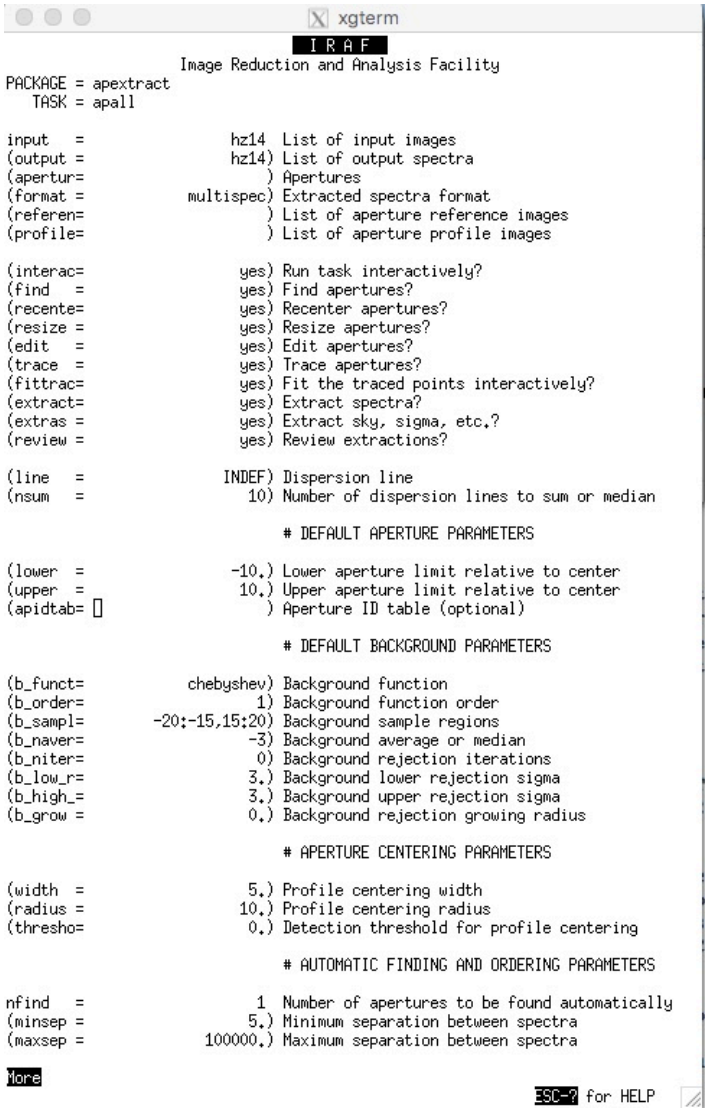
- Will use the spectrophotometric standard hz14 as example.

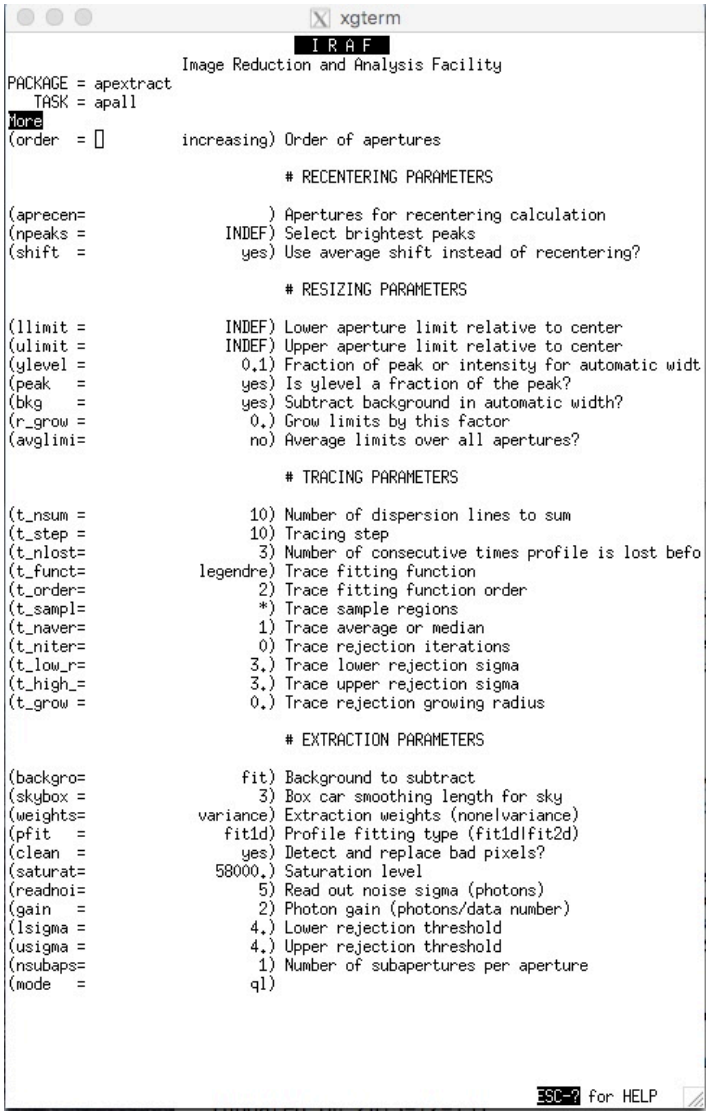
cl>display hz14



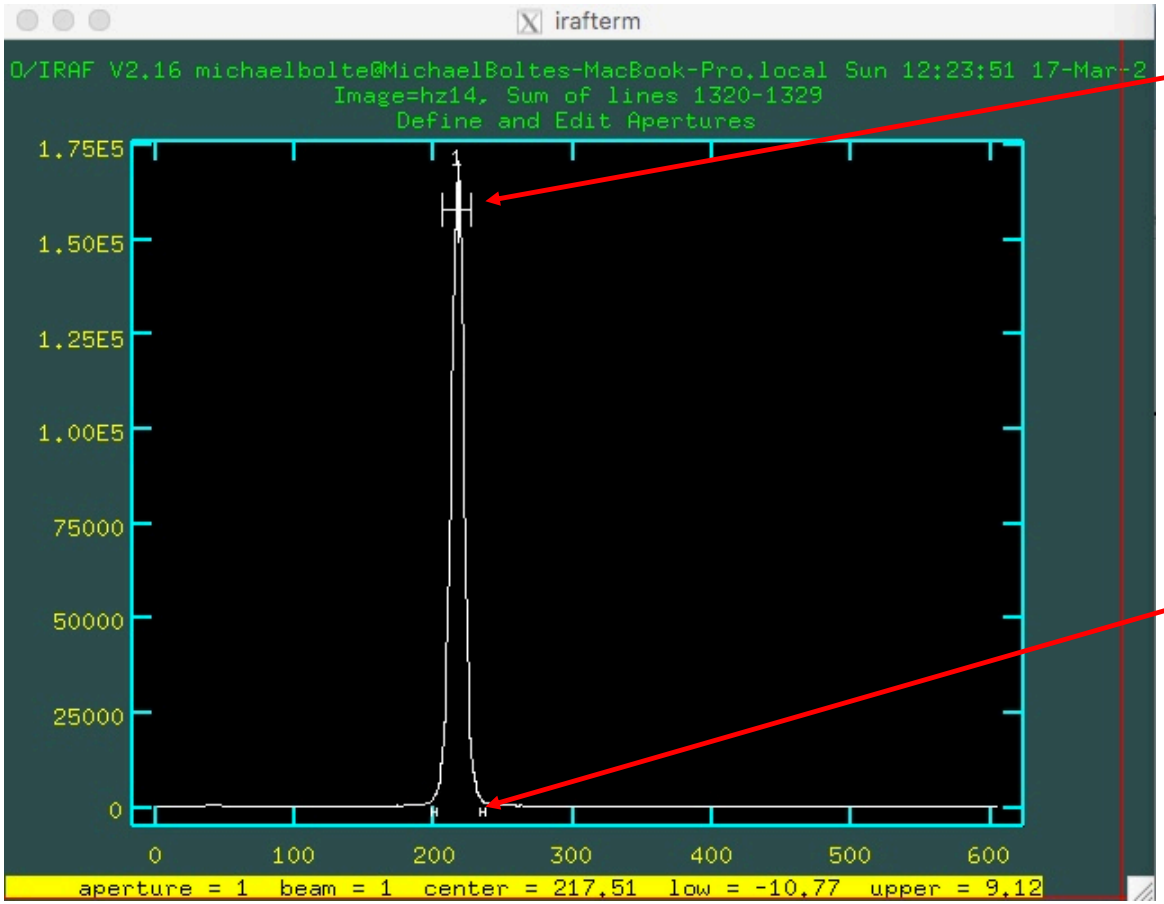
Set parameters in *apall:*

epar apall



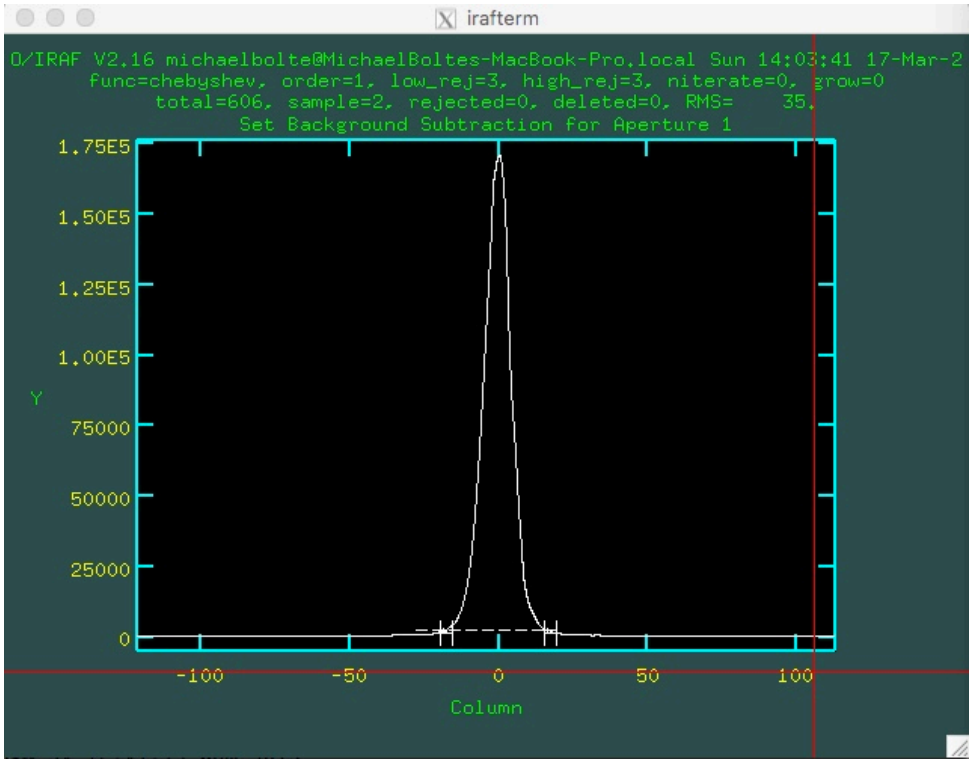


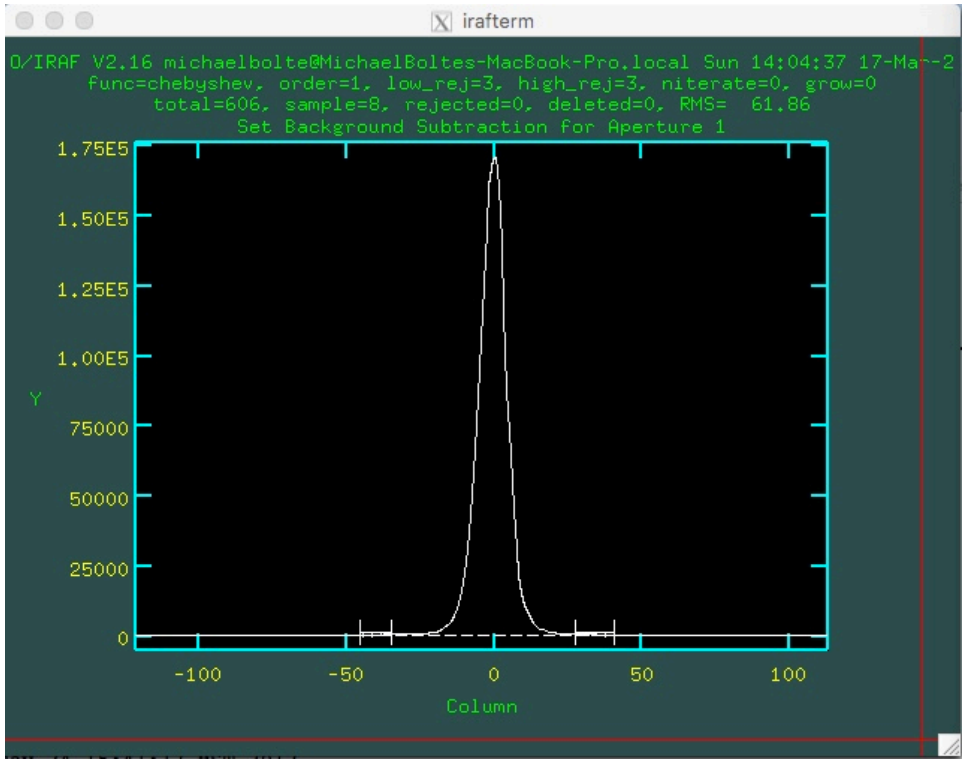
Graphics window pops up



Lower and upper limits of the extraction aperture. Place cursor on lower-side aperture edge and use “l” to reset, place cursor on upper-side edge of the aperture and use “u” to reset

Initial setting of the background apertures had them too close to the aperture with the result that you subtract the stellar spectrum from itself. Typing “b” will put you into the ”background set” mode (next slide)



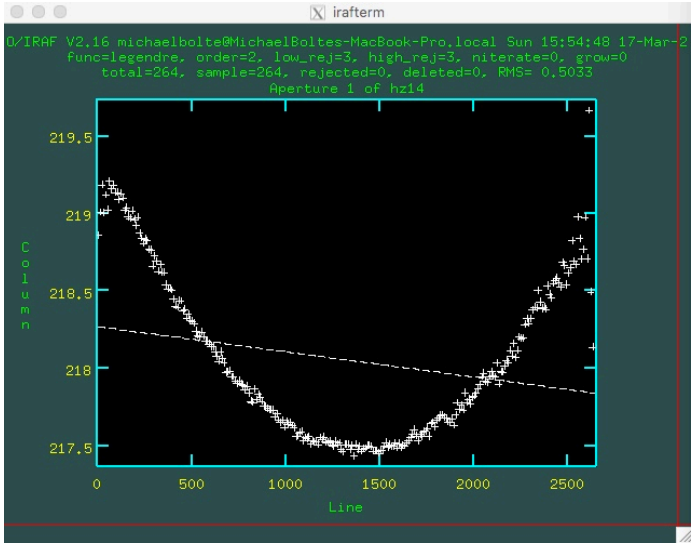


Initial background samples and fit to background level. Got here by typing “b” in previous aperture window. Use “z” to delete the background aperture closest to the cursor, then “s” to define a new aperture with the cursor

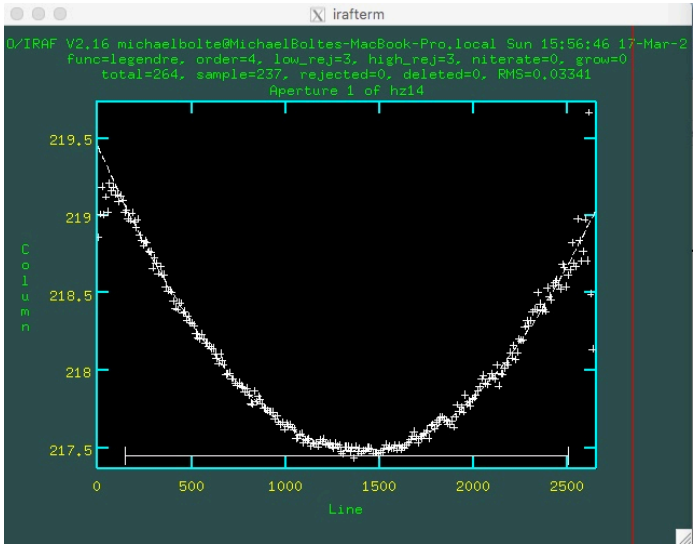
Result of using “z” twice to get rid of the original apertures, “s” twice to define two new sky apertures, then “f” to make the fit between sky apertures. When you are happy with your background apertures and fit, use “q” to go back to the main aperture plot

Trace

When happy with the aperture and background, type “q” from aperture window and respond “yes” to interactively trace the aperture and this will pop up.



In the window use ”:o 4”, followed by “f” to set the fitting order to 4 and refit. Note that I used ”s” first to reset the sample to ~100 to 2450 on the x axis to avoid using the funny stuff at the end of the trace in the fit.

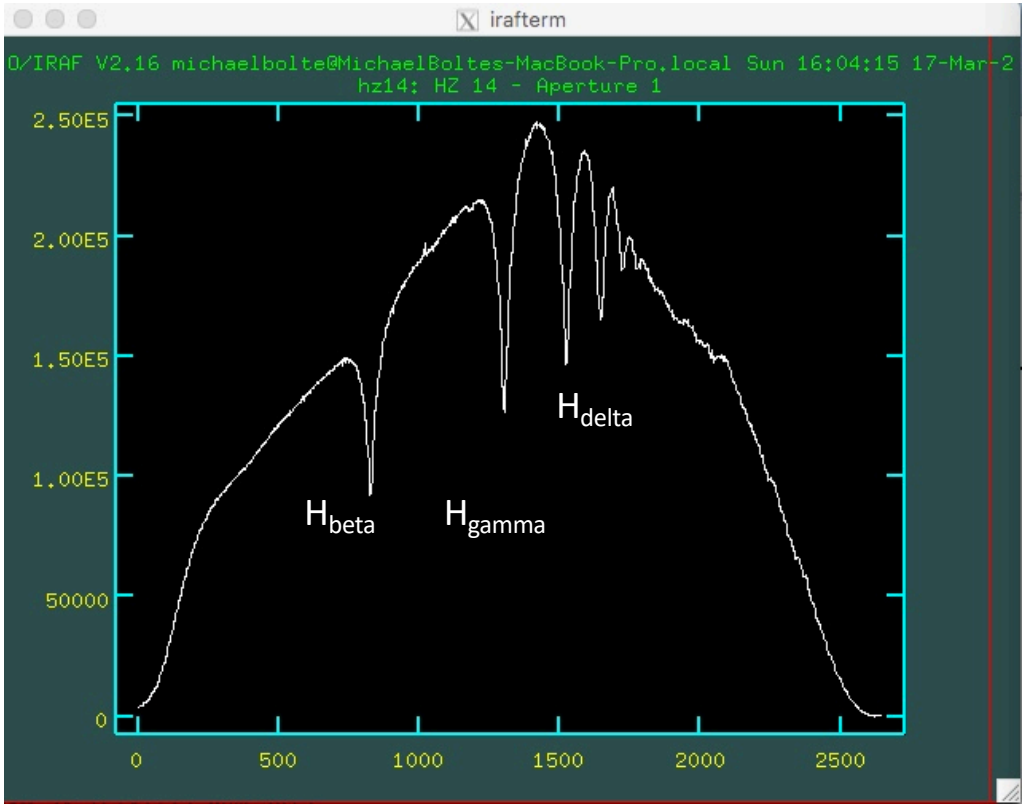


Extract and review the spectrum

Answer “yes” (several times) to questions about extracting and reviewing the spectrum and you have it!

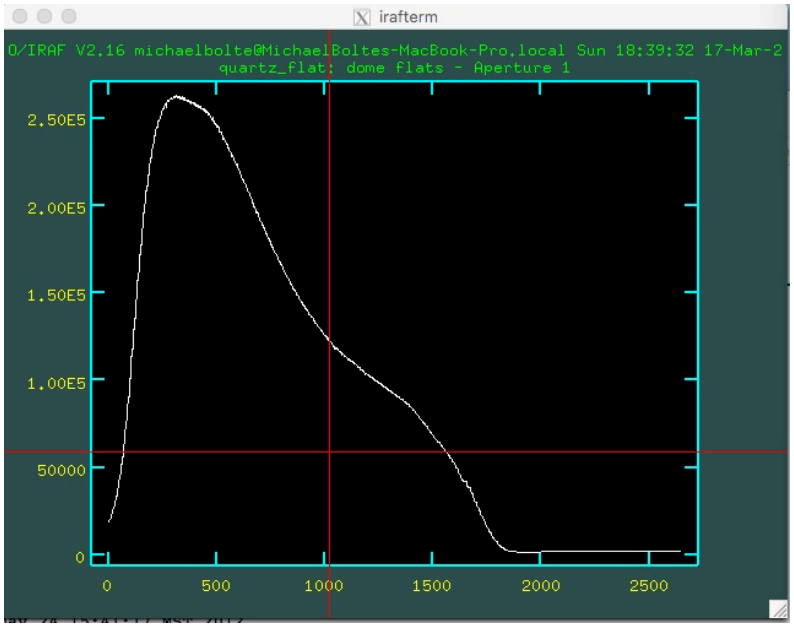
hz14.ms has the extracted spectrum (intensity vs pixel), extracted sky, and a S/N plot

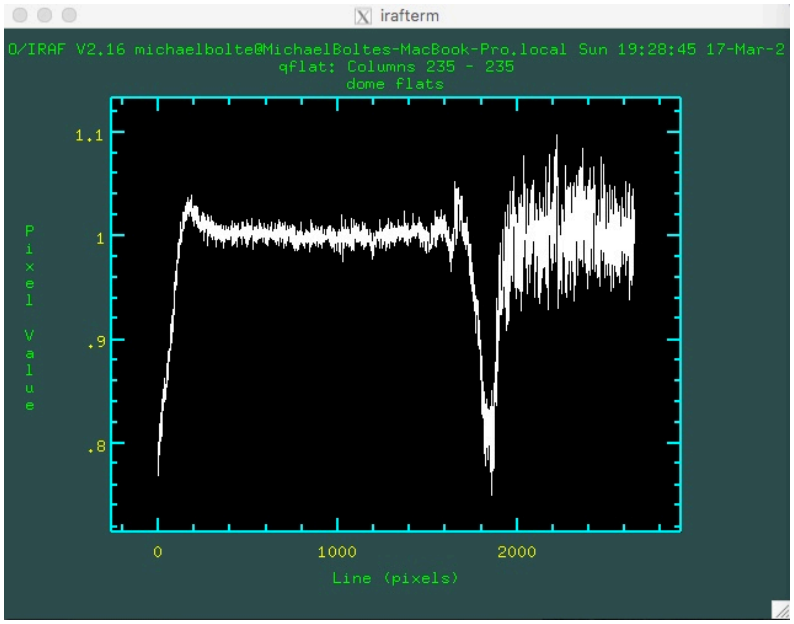
You can go back to *apall* and reset the Default Aperture Parameters and Default Background Parameters and they will be betters starting points for subsequent extractions of the other spectra



Flat-fielding

- The flat-field image is a spectrum of a quartz lamp: more-or-less a blackbody continuum. In order to use that spectrum as a flat-field the variation in the spectral dimension needs to be removed as that is just the spectrum of the bulb and has nothing to so with the sensitivity of the detector
- You can fit a low-order function to the flat-field and divide it into the original and then extract the same aperture/trace as the stellar spectrum or you can do the extraction and then normalize the extracted spectrum
- I'll try both

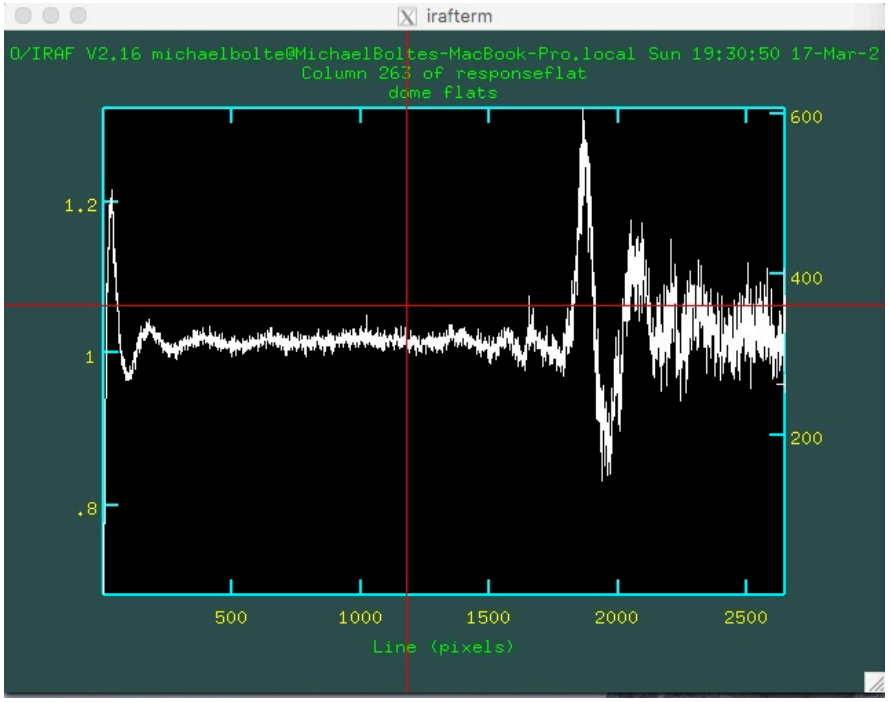


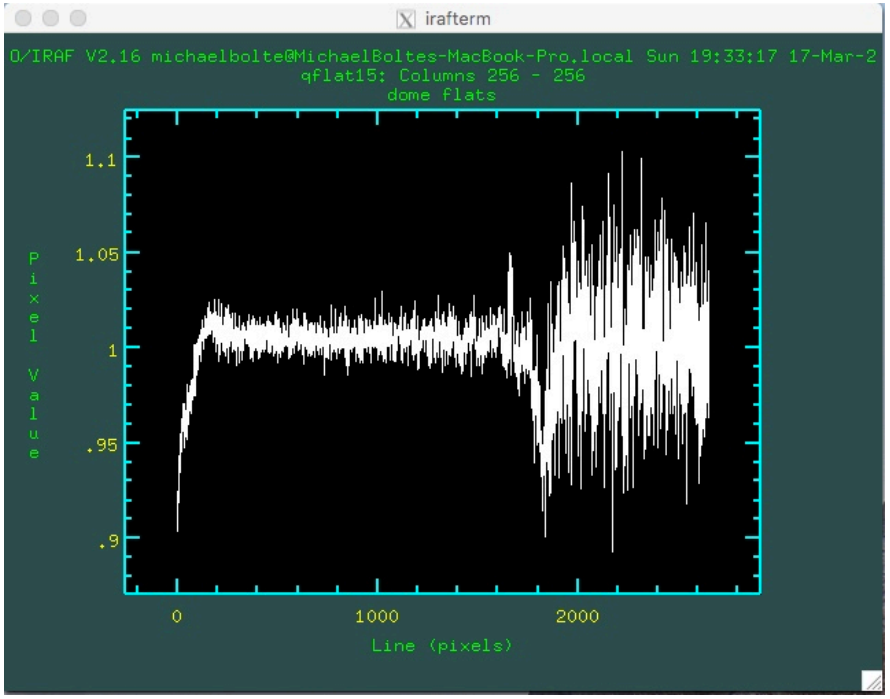


This is the extracted flat

This is after dividing out a 22nd-order polynomial fit

Not very good! Between around pixel 200 and 1600 it is OK but probably do more bad than good to use this





This is a cut along a column after (1) doing a gaussian smooth of the 2-D flat using a 30-pixel kernel and (2) dividing the original image by the smoothed version

This is a cut along a column after (1) doing a gaussian smooth of the 2-D flat using a 15-pixel kernel and (2) dividing the original image by the smoothed version

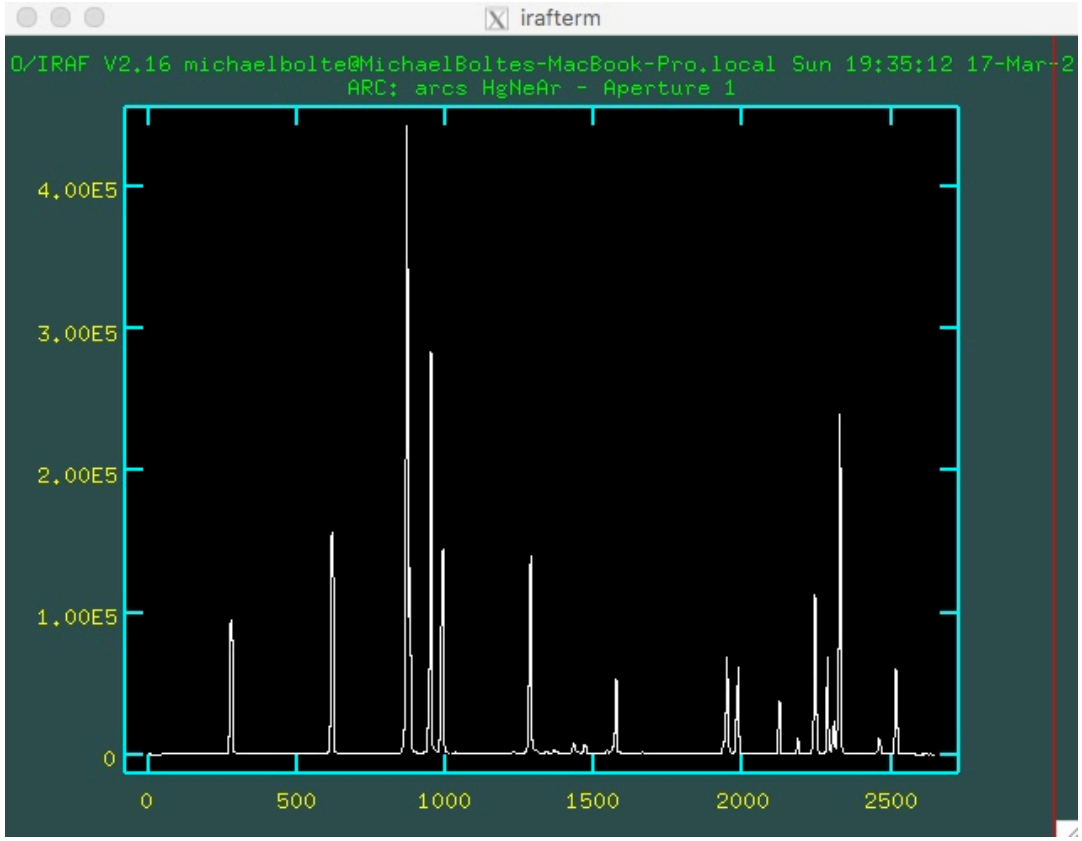
This looks better, but not enough light beyond pixel 1700: conclusion, don't flat field

Wavelength calibration

Use apall to extract ARC spectrum with the hz14.ms aperture/trace as was done with the quartz flat (no background subtract, use aperture based on hz14.ms)

identify is the task used to

assign wavelengths to arc lines and map pixel to wavelength

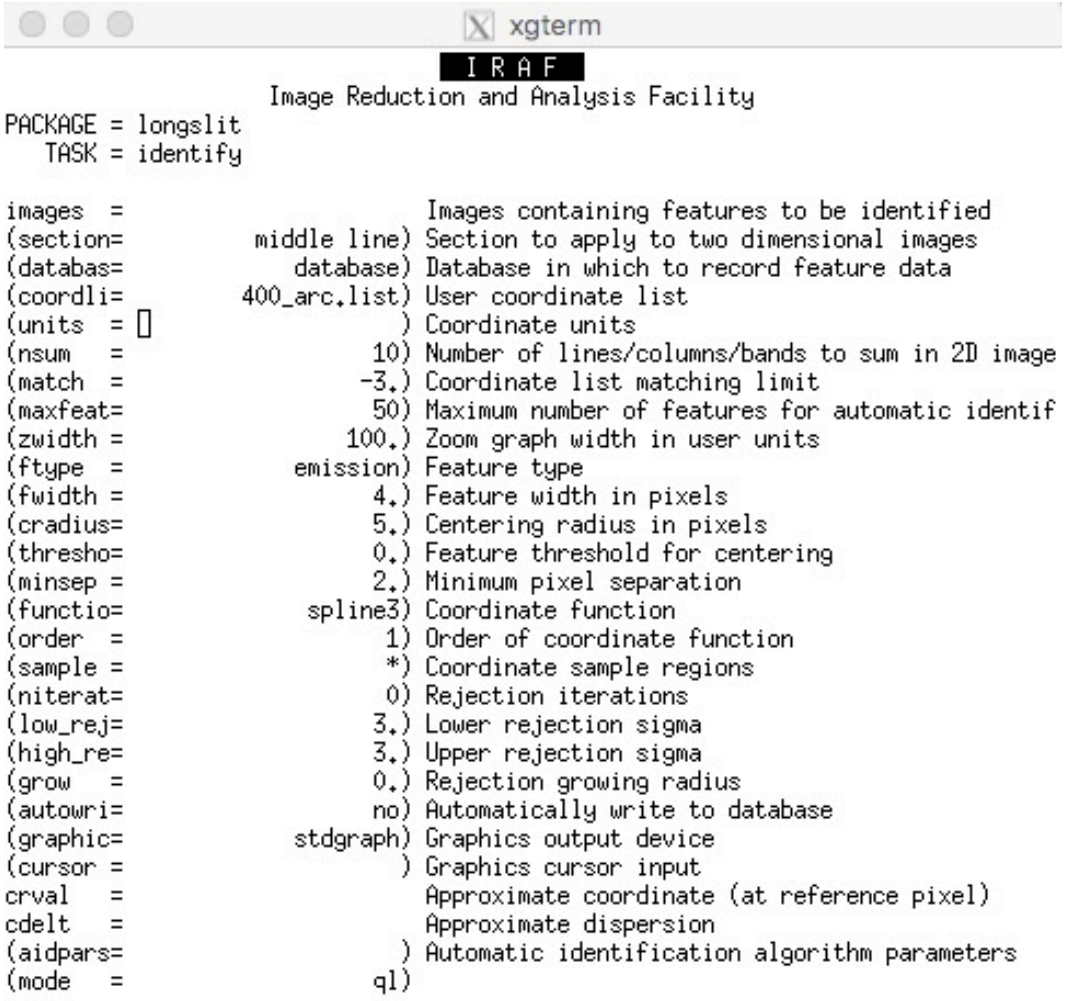


Identify

Need to give it:

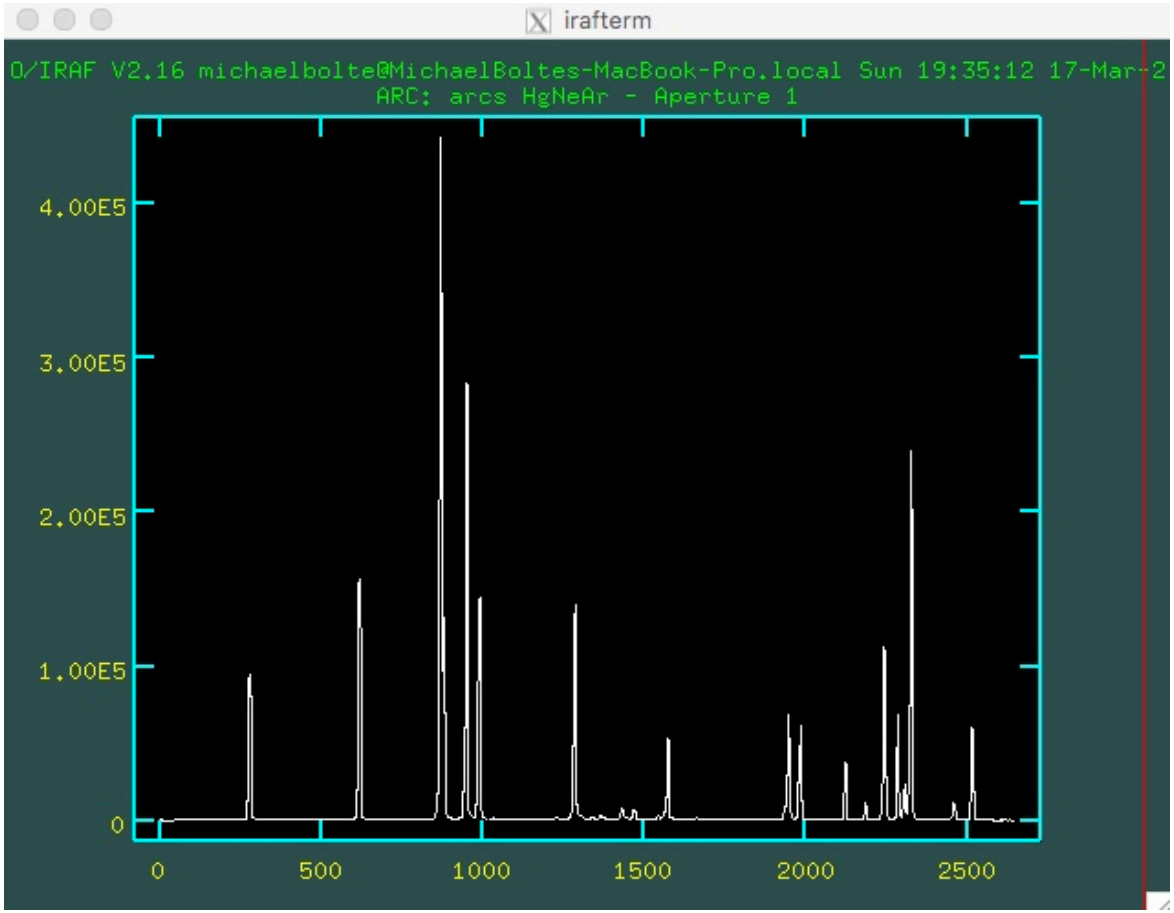
(1) an arcline spectrum (ARC.ms) and,

(2) a line list (400_arc.list in the working directory)



Use the cursor on a line a “m” (mark) to type in three or four line wavelengths based on 400_arc.pdf identifications

Note that the wavelength scale is reversed initially with respect to 400_arc.pdf file

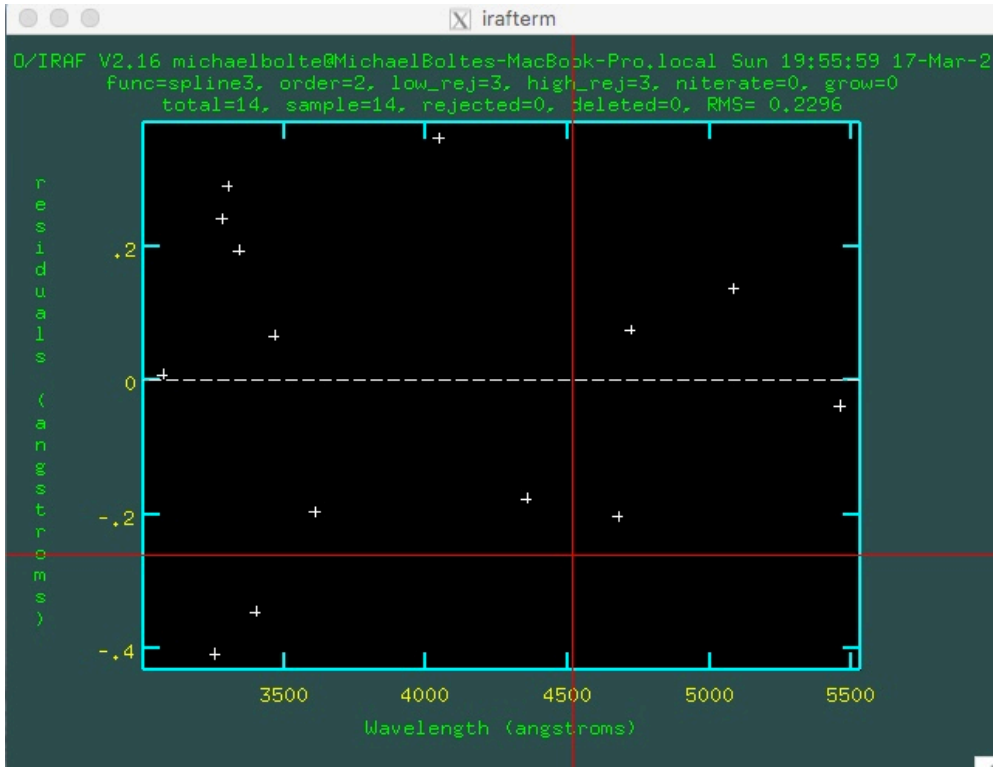


The art of fitting arc lines

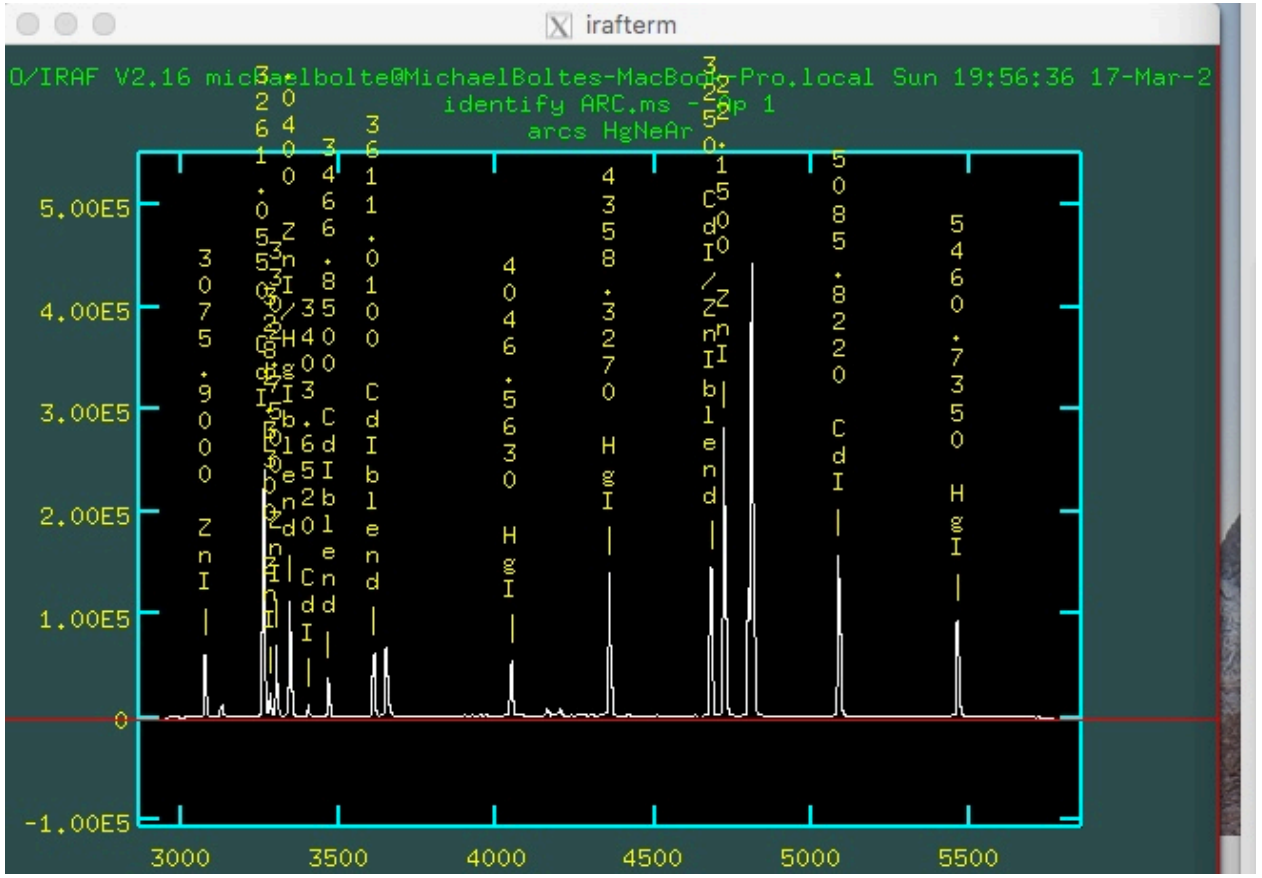
The first time you run *identify ,* find a line ID by matching patterns in 400_arc.pdf , center the cursor on it, type “m” and enter the wavelength. Do this for three or four lines then type “f” (for fit)

That will produce the panel on the right. This shows the residual from the best fit of each identified line. The fit order is shown as is the RMS residual. Move the cursor to a point type “d” then “f” and it will refit without that point (put the cursor near the deleted point and type “u” to add it back to the mix). Experiment. Sometimes deleting one or two points will improve the fit a lot.

Type “q” to go back to the spectrum



With the preliminary fit done, now if you center the cursor on a line and click “m”, it will calculate the fit based on the current solution and search through your line list (400_arc.list) for a nearby match and assign that wavelength. Do this for all the clean lines, type “f” again to go to the fitting plot and remove any serious outlyers.



Refspec and dispcor

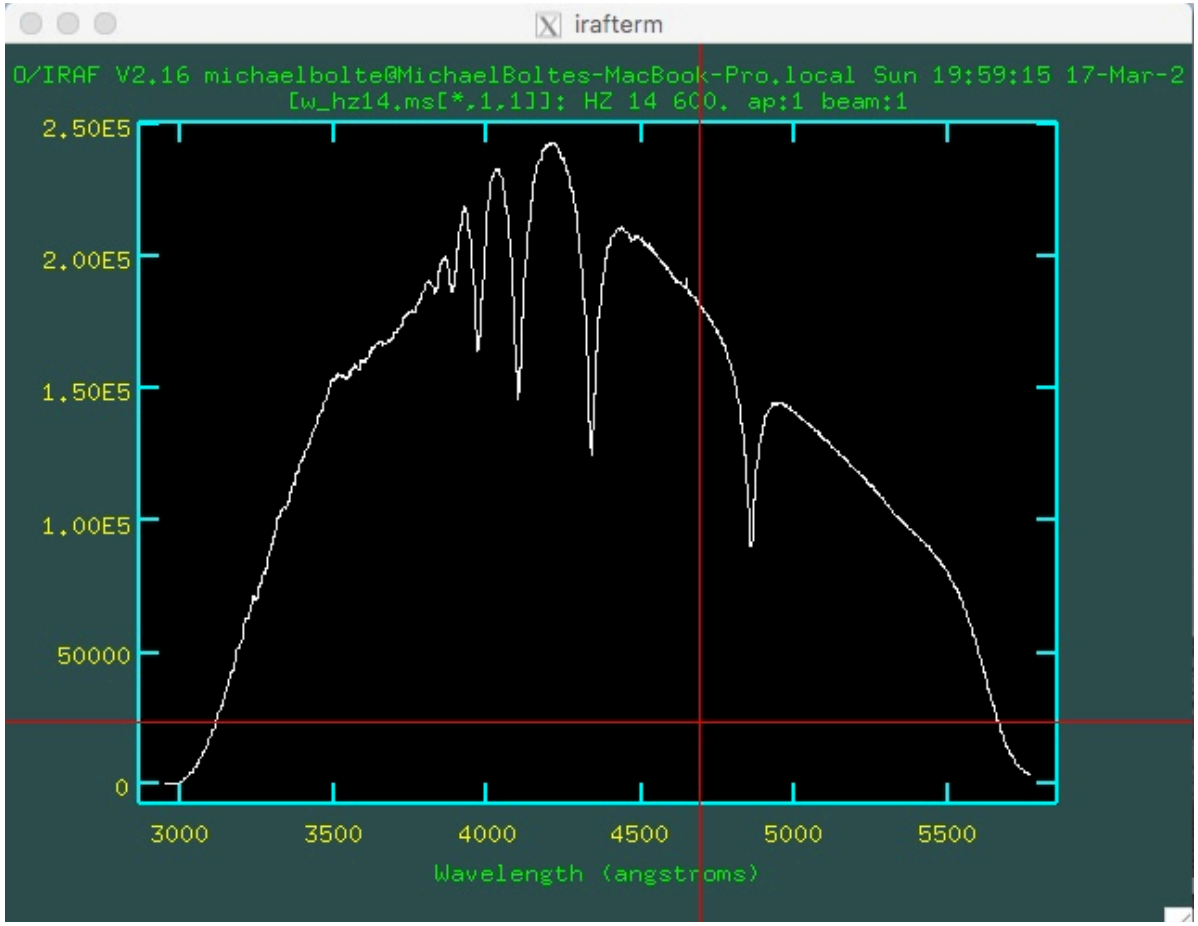
Now associate the arc solution with your extracted stellar spectrum using the task *refspec*

twod> refspec hz14.ms ARC.ms

Finally, write a linearized wavelength scale into the stellar spectrum header using *dispcor*

twod> dispcor hz14.ms w_hz14.ms

twod>splot w_hz14.ms will produce the plot on the right

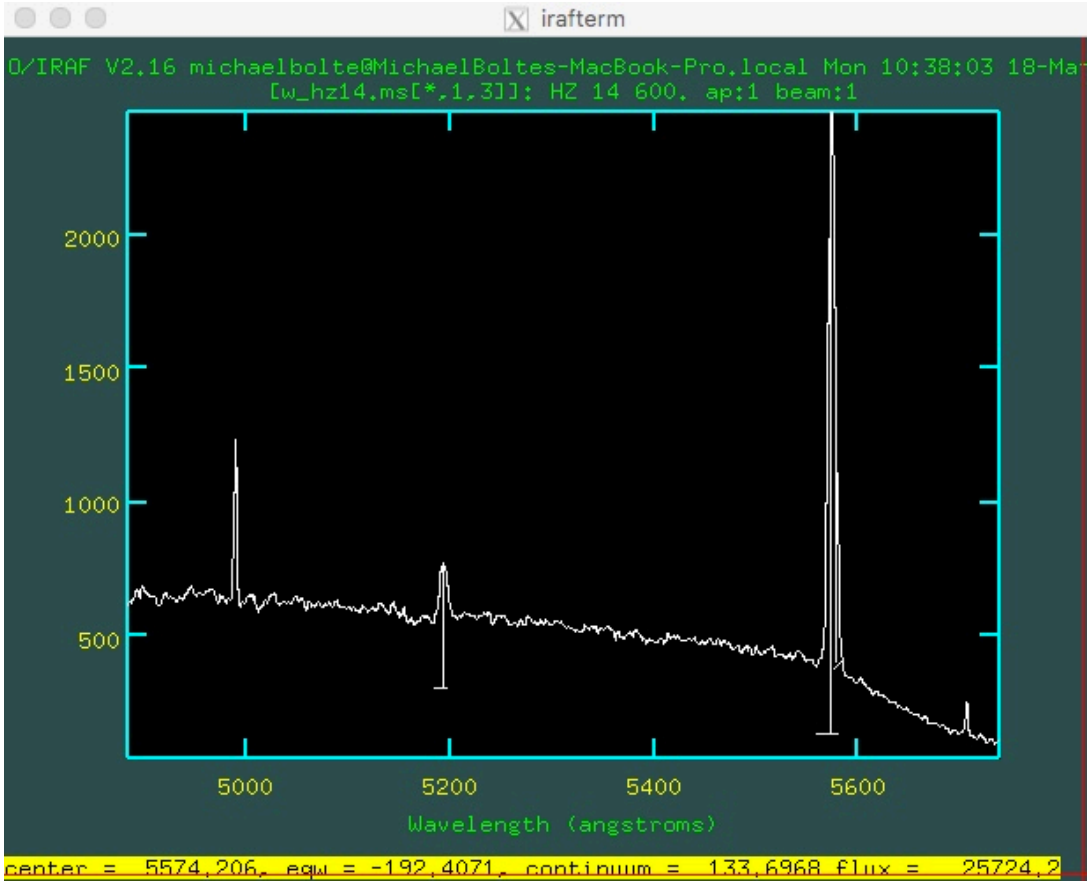


Splot for line centers

If plot “band 3” from w_hz14.ms, this is the extracted sky. The strongest emission line is:

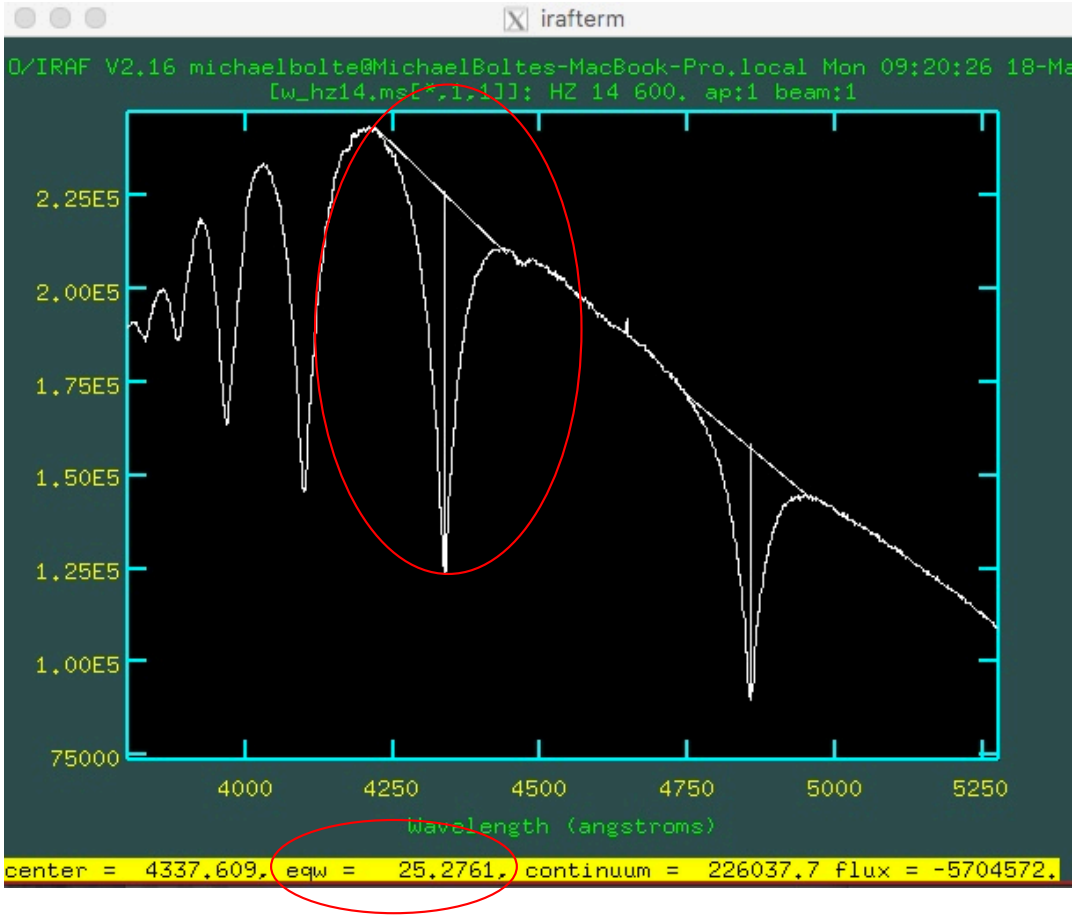
Oxygen forbidden line at 5577.34A, measured in the spectrum at 5574.2

The arc lamp was observed in the afternoon, hz14 at night so the 3.1A offset is likely due to flexure and this offset should be added as a zeropoint correction to the wavelength solution for hz14



splot to measure line properties

- For this assignment, you can use splot to measure the hydrogen Balmer line equivalent width.
- Handy commands are “w” for windowing the plot
- “e” for selecting two continuum points and measuring the equivalent width
- H_{gamma} example line center and equivalent width.

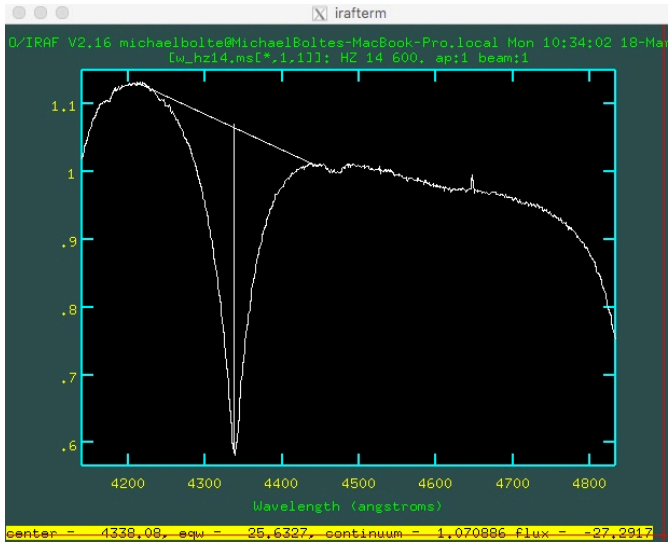


HZ14 radial velocity

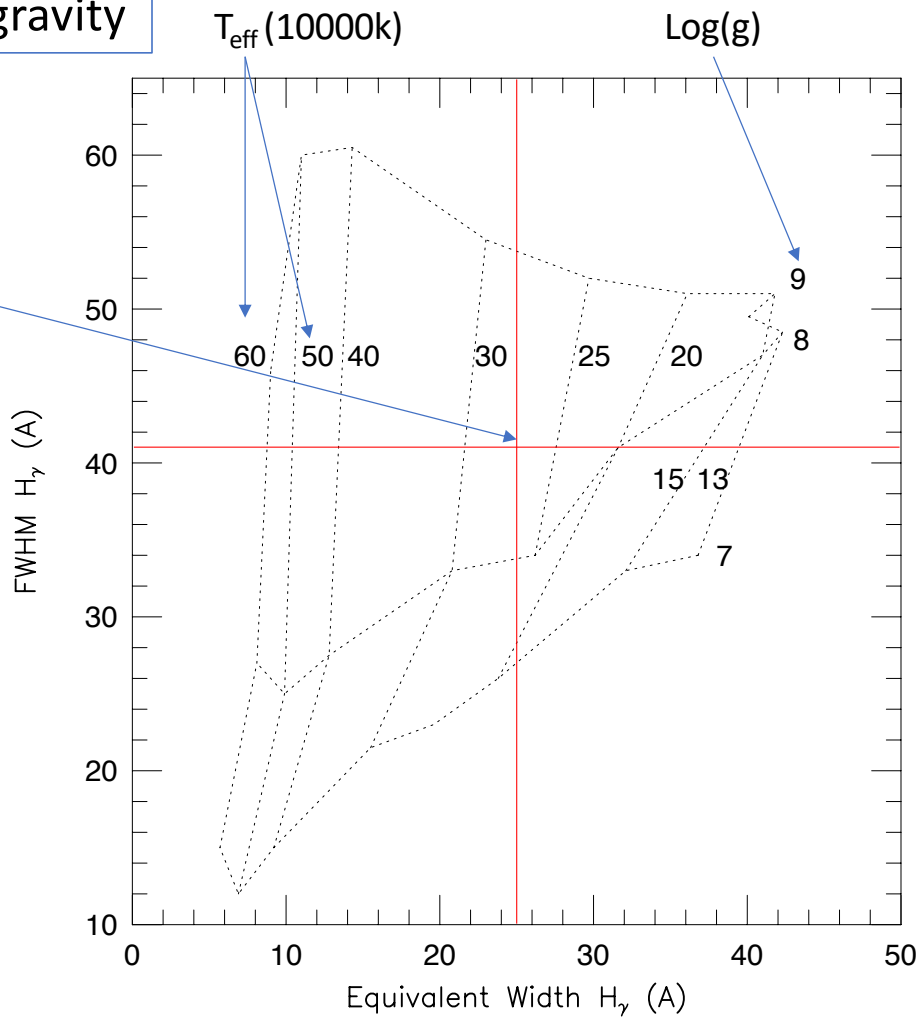
- Measured Hγ line center: 4337.61A + 3.1A (offset from sky line) = 4340.71A.
- Rest wavelength for H_γ is 4340.46A
- $v = \Delta\lambda/\lambda_0 \times c = 0.05/4340.46 \times 3 \times 10^5 = 3.5$ km/sec

HZ 14 surface temperature and surface gravity

Looks like T_{eff} ~27000K, log (g)~8.3



H_γ FWHM=41(A), EW=20.5 (A)



A note

- Most of the candidate white dwarfs were indeed white dwarfs. There were two background QSOs and one G-star