

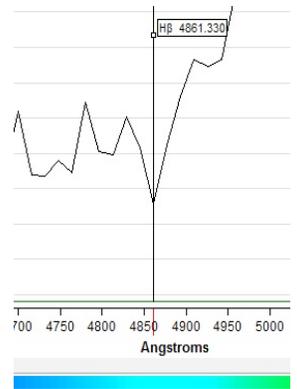
Lab 12 -Processing Diffraction Grating Spectra with RSpec

Purpose

Here we use RSpec <http://www.rspec-astro.com> to process and calibrate our diffraction grating spectrum. We can then determine the wavelength in angstroms, of various features in our data. RSpec also contains a reference library for identifying hydrogen, and other Balmer lines.

http://en.wikipedia.org/wiki/Balmer_series

The calibrated spectrum graph can be used to measure red-shift of quasars, identify Wolf Rayet stars, http://en.wikipedia.org/wiki/Wolf-Rayet_star and measure the expansion of Type 1a supernovae. Tutorials are also available on RSpec website. <http://www.rspec-astro.com/more-videos/>

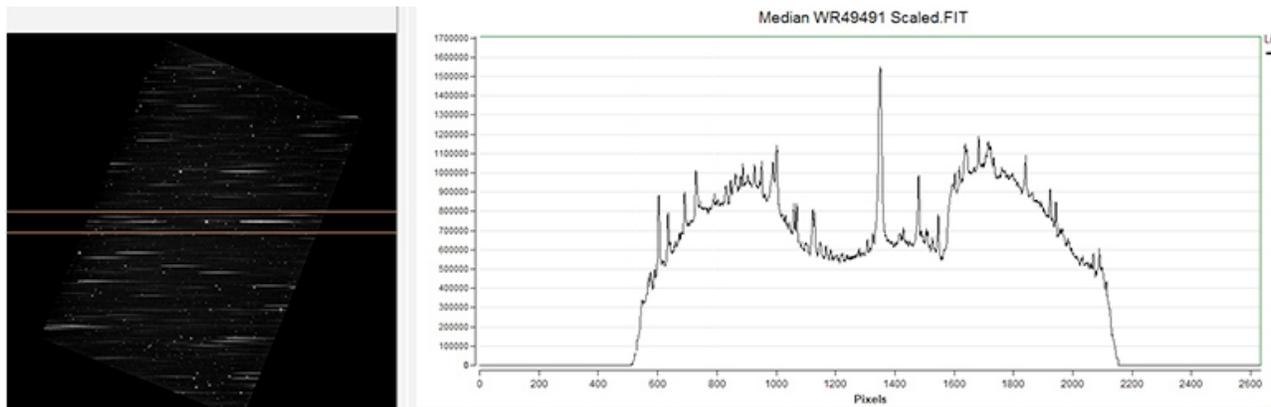


H-beta. RSpec

Procedure

Start RSpec and open your target file by selecting the **folder icon** in the upper left and navigating to your image. The main RSpec window presents the .fits image on the left with an un-calibrated profile graph of the image to the right.

To familiarize yourself with RSpec, left click anywhere in the graph and use the mouse roller to enlarge that region or feature. Double clicking anywhere in the graph returns you to the full graph.

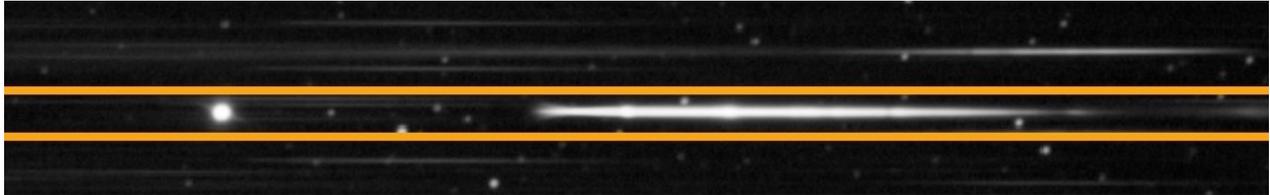


RSpec screen showing spectra image on left, profile graph on right.

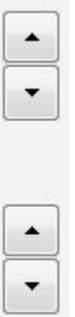
In the image area on left, left-click hold to individually move the orange **cropping bars** to crop close to your spectrum. Notice how the profile graph updates with each adjustment.

To isolate the target spectrum, choose the **Zoom** tool  from RSpec's main window to create a new window with a closer view, and cropping bars. Use the mouse roller to zoom in and out of the image, and left-click-hold to position the image as needed.

Use two sets of arrow buttons on the right, for final cropping to the spectra. The top two buttons move both bars, the bottom two move the bottom bar only. Crop close to just include the horizontal spectra and your star as seen here, then exit the zoom tool.



Target star and spectrum, cropped in RSpec.



In RSpec's main window, on the profile graph at right, notice the X axis is in pixels (The ST-10 has ~2600 pixels on the X axis). We will now calibrate our spectra, and convert pixels to wavelength in angstroms. To do this, RSpec needs two parameters: the "zero" point of the actual star, and the dispersion of our setup, in angstroms/pixel.

<http://violet.pha.jhu.edu/~wpb/spectroscopy/measure.html>

Click on the **Calibrate** button below the profile graph to bring up the Calibration Wizard. A yellow box appears with a blinking cursor. Here we want to input the zero-order pixel number of our star. This can be found by hovering the mouse over the high point of the star in the graph. Simply click this point to enter that pixel number in the yellow box, and check the **Zero** box to confirm this is our zero point.

The dispersion with the ST-10/200 line diffraction grating in this setup has been predetermined at 16.15 ang/pixel. <http://www.youtube.com/watch?v=5peF8laJYLo> In the Calibration Wizard window choose **Use One Point Alignment**, and in **Angstroms/Pixel** type 16.15. Hit **Apply** at bottom. RSpec now shows the calibrated spectrum in the profile graph on the right. The graph shows angstroms on the X axis, and intensity on the Y axis. Left click the **Adjust icon** on right  to also show the synthesized color spectrum.

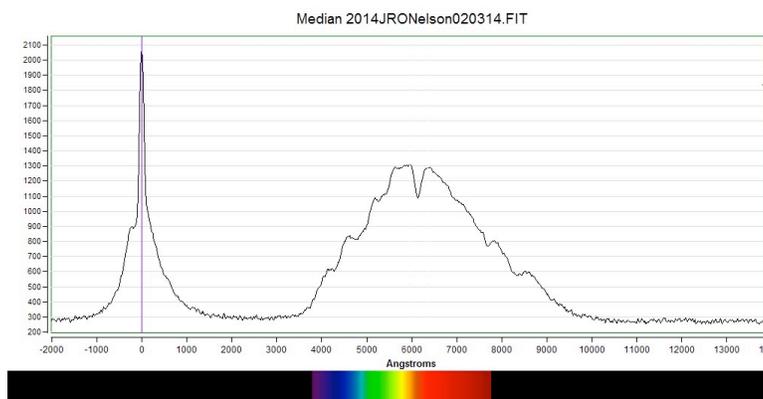
Crop the graph to personal preference, or for a closer look at a particular feature, such as an absorption or emission line:

Left-click anywhere in the graph and use the mouse roller to enlarge the image, centered on that point. Alternatively, hold the shift key and left-click drag to crop to any region or feature of the spectrum.

Another important option is to left-click hold, to center a particular region or feature, in the graph. After cropping and positioning the graph, hit the **Adjust button**  again, to update the color bar. Double clicking anywhere in the graph returns to full view.

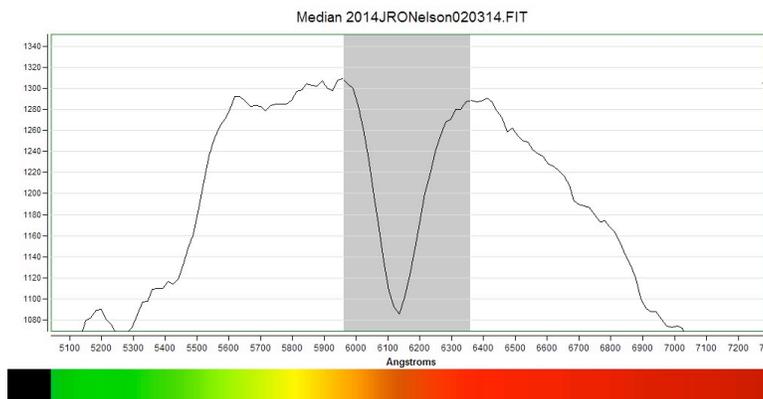
Following is an example using RSpec to process diffraction grating spectra taken in the observatory of supernova SN2014J on 020414UT. The dominant spectral feature to look for in a Type 1a supernova is the Si II (silicon) line at 6355Å. This **standard wavelength**, (6355Å) and our **observed wavelength**, will then be used to calculate the expansion rate of SN2014J on 020414UT.

After loading the data to RSpec, and performing calibration, we see the spectrum of SN2014J centered between ~4000 and 9000Å. The tall peak at left (zero), is the star. The distinct “V” shaped feature located near 6355Å is Si II. This will be used to determine the expansion rate.



Calibrated spectrum of SN2014J

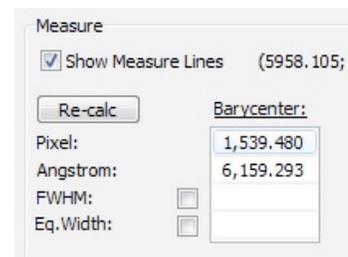
We now crop to our Si II feature for precise wavelength measurement. Click in the middle of the silicon region and scroll in far enough to see the top and bottom of this feature, as seen here. Next, choose the **Crop** tool  from the main window to show the vertical cropping bars.



Close up of Si II region.

The area between the cropping bars is greyed out. Both sides are manually positioned (left-click-drag) to mark the left and right sides of our feature. Position both the left and right cropping bars at the top of the absorption feature. One side may be slightly higher in the continuum. <http://casswww.ucsd.edu/archive/public/tutorial/Stars.html>

Since we are calibrated in angstroms/pixel, the center of the grey cropped area tells us the **observed wavelength** of the Si II region in our data. Be sure **Show Measure Lines** is checked in the Measure window to show the observed wavelength of our feature, (i.e. 6159.2) in angstroms.



“Measure” window. RSpec

Expansion rate calculation and labeling.

Using both the observed wavelength, and the standard wavelength of our Si II feature, and the speed of light, (300,000 km/s) we can determine the expansion rate of our supernova, using the standard formula below. RSpec also has tools for creating a graph title, and labeling various features.

Open the **Appearance** window and in the **Graph tab**, uncheck **Fill Between Measure Lines** to undo the grey between the cropping bars. Open the **Labels** tab. We will mark the Si II region first. Click **Label 1**, and in the **Label Details** window, under **Wavelength**, enter the *observed wavelength* of your feature. (i.e. 6159)

In the **Text** window type a pointer (< or >), the feature's name, and the calibrated wavelength in angstroms (i.e. < Si II 6159 Ang.). This text will appear in the graph, and can be accurately positioned using the horizontal and vertical scroll buttons located in the **Label Details** window.

Click on **Label 2** for a new label. Here, we will enter and position our observed expansion rate for SN2014J. Expansion rate is determined using the *standard wavelength* of our feature, the *observed wavelength* of our feature (Si II) and the speed of light, with the formula:

$$\text{Expansion} = (\text{observed wavelength} - \text{standard wavelength}) / \text{standard wavelength} * c$$

Using this example we have:

$$(6159 - 6355) / 6355 * 300,000 \text{ for an observed expansion rate of } -9000 \text{ km/s}$$

Enter the expansion rate and position this text in the graph as needed. In the image below, we have optionally included and labeled the star position, and filled in the title bar at top.

