Lab 10 - SGS Processing – Stellar Radial Velocity, Planetary Rotational Velocity

Purpose

In Lab 10 we'll process our stellar spectra to measure radial velocities of stars, and explore differences of various spectral types. We do this by looking at the star's Fraunhofer lines using Vspec. http://en.wikipedia.org/wiki/Fraunhofer_lines

We will also analyze our spectra of Jupiter to determine its current motion (Doppler) either toward or away from Earth. We can determine Jupiter's rotational velocity from measurements taken on both sides of the planetary disc.

Procedure

First, we need to dark subtract images taken with the SGS. This includes calibration spectra images. As we have seen, time and temperature of our dark frames must match the image frames, to record and subtract noise from the data.

Dark Subtracting Images Using Maxim DL

According to the manufacturer, dark frames for SGS data are best taken every night, https://www.sbig.com/site/assets/files/18237/sgs_manual3.pdf We do not use flat fields.

Open Maxim DL. From the main menu go to: **Process > Calibration Wizard.** In **Calibration Wizard** window: Hit **Next > Next** (temperature is regulated) Choose **Manual** from the pull down menu (we manually select the images) then **Next > Next** (bypass Select bias frames).

Under **Select one or more dark frames**, hit the navigate button then navigate to, and open the appropriate dark frames folder on the desktop. This is normally **5min1bindark** for stellar spectra and **1min1bindark** for planetary or calibration spectra.

Select the dark frames and hit **Open**. In **Calibration Wizard** window, hit **Next > Next** (to bypass flat field frames) then **Finish.**

In the **Set Calibration** window, change **Combine Type** to **Median.** This helps mask cosmic ray hits in the data. Click **OK** at top of the menu. A master dark is created and queued to Maxim DL**,** and the Calibration window disappears.

Open your spectra images in Maxim DL**: File > Open** and navigate to the correct folder and choose the light frames (or calibration spectra) to dark subtract. Select **Process > Calibrate All** and wait. All loaded images are now dark subtracted with the master dark just created. To save these, choose **File > Save All**, or save individually as needed. Images are now dark subtracted and ready to process.

Doppler and Radial Velocity Measurements with Vspec

Procedures for line identification and cropping are the same as previous Vspec procedures in ASTR 203 Lab 10, p.38-39

Procedure
Start Vspec and open the stellar spectra and calibration spectra of your target, and process as usual.

Choose Line to Measure
Locate the absorption feature in the image that you will use to measure the radial velocity, typically Hα at ~6562.81Å.

Adjust **Scale Y** and **Scale X** to concentrate on your absorption line: On **Axis Y** set **Hi** and **Lo** thresholds and choose **Display Gridlines**. On **Axis X** set **min** and **max** thresholds.

Radial Velocity
On X Axis check **Doppler** and enter **Lambda** (wavelength). Hα=6562.81, Hδ=4101.75

Set **Nb ticks** and **Tick** to 20, to show *approximate* km/s in 20 km/s increments on the X axis. Hit **Apply**. Negative km/s shows blue shift, towards Earth. Positive km/s shows red shift, away from Earth.

To determine more accurate RV, first identify your observed lambda (λ). Use the vertical red bar to mark both sides of your absorption line (**left-click drag and use arrow keys**).

In the middle of your chosen region, choose **right-click > Label**, and Vspec will mark the center wavelength of your absorption feature. This is used to calculate radial velocity:

To determine radial velocity in kilometers per second: $V_{rad} = \frac{\lambda_{obs} - \lambda_0}{\lambda_0} * c$

V rad =
[observed wavelength - rest wavelength] / rest wavelength x c

λ_0 Hα = 6562.81Å λ_0 Hβ = 4861.34Å c = 299,792 (km/s)

Create Title Box and Save
Under **General tab**, first click **Header** to display UT date and time from the .fits header. http://fits.gsfc.nasa.gov/fits_primer.html Under **Graphic title** list the star name, spectral type and Vmag. Under **Comment** list your radial velocity results using the above formula. Hit **Apply**. In Axis X check **Display title** and Apply. Reposition the **Title box** as needed.

To save the image, move the vertical red line out of the image area, then **File Export** .jpg to the appropriate location.

Jupiter
Spectra of Jupiter taken with the SGS is processed as normal in Vspec to identify Hα and the broad methane region in the spectrum.

Rotational velocity can also be determined from data taken with the slit located near the left and right edge of the planetary disc (p.32). The prominent Hα line will be used for this.

Procedure
Process your two planetary images in Vspec as usual, and measure the velocity of both the left side, and right side of Jupiter's disc. One side will be distinctly blue shifted (shorter wavelength). To measure rotational velocity RV, subtract the two velocities, and divide by 2.

Rotational V = $V_1 – V_2 / 2$

SETI http://www.seti.org has planetary ephemeris generator tools, for additional investigation and comparison. http://pds-rings.seti.org/tools/ephem2_jup.html