

ASTR 4880/PHYS 5880 — Fall 2008 – Homework Assignment 1

Due: October 8, 2008

On the next page, Table 1 gives the basic properties of Ritter Observatory's two spectrographs. For this assignment, please be sure to use the values given for the *échelle spectrograph*.

On the third page, Figure 1 shows the image display of an échelle spectrum of Deneb, which is to be found in `/mnt/vol101/ndm/iraf/course/F2008`. In it, H α ($\lambda = 6563 \text{ \AA}$) is marked with a number 1, and two other features are marked with the numbers 2 and 3. In this illustration, wavelength increases from bottom to top (increasing y) and from right to left (decreasing x).

Our CCD has dimension 2048×2048 pixels, each pixel $30 \mu\text{m}$ on a side.

Owing to the repetitive nature of some of these calculations, you may want to perform them in a spreadsheet. For each part, however, turn in at least one calculation fully written out, showing all steps, and make sure that your printed spreadsheet displays all the numerical values you used.

1. The grating equation is: $n\lambda = h(\sin \alpha + \sin \beta)$. From this equation, derive the formula for the angular dispersion, as done in class.
2. Using the cursor in *ds9*, read off the x and y coordinates (in pixels) of features 1, 2, and 3 and write their values in a table.
3. Also in *ds9*, estimate the y coordinate of the center of the échelle blaze pattern (where the spectrum is brightest).
4. Using the information given in Table 1, calculate β (relative to the échelle grating; call it β_E) for the three marked features.
5. Assuming that the cross-disperser's β angle is $\simeq 0$, calculate the angular and linear dispersions of the échelle and the cross-disperser at the β_E angles of the three features.
6. Roughly estimate the wavelengths of features 2 and 3.
7. Calculate the linear dispersion of the échelle in \AA per pixel at each of the three features.
8. Using the grating equation in the form $n\lambda = \text{constant}$ (i.e., for constant β_E), calculate the wavelength at the β_E of H α for $n = 34 - 58$. Why are the orders more closely spaced toward the right-hand side of the image?

Table 1: Ritter Observatory Spectrograph Characteristics

Spectrograph	Low-Dispersion	Echelle	Echelle
Grating	6	Echelle	Cross-disperser
Grating:			
Grooves mm^{-1}	1200	79	150
Diffraction order at $\text{H}\alpha$	1	34	1
Incidence angle α ($^\circ$)	0	68	0
Blaze angle θ_B ($^\circ$)	27	63	2
Collimator:			
Focal length (cm)	100	54	54
Diameter (cm) ¹	10	7	7
Camera:			
Focal length (cm)	20	75	75

¹ Echelle: mirror is a 67×67 mm square

Notes:

1. In the above table, some values are rounded off.
2. The resolution of the échelle spectrograph is limited by astigmatism to about $\Delta x = 20 \mu\text{m}$ in the focal plane of the camera mirror.

Figure 1: Display of a spectrum of Deneb with *ds9*

