ASTR 306/406 Homework #4

1. Spectroscopic setup (15 points)

Arriving at the observatory for my spectroscopic observing run, I find that the only grating I have available is a 300 line/mm grating blazed at 8000Å in the first order. But I want to observe in the blue from 3500Å to 5000Å.

- How could I best do this and what precautions should I take?
- At what angle will 4000Å light be found relative to the grating normal?
- What is the blaze angle of the grating?
- What camera focal length should I use to fit the spectrum on a CCD 20mm wide?
- If the 2 arcsecond wide slit projects to 66 microns on the detector, what is the spectral resolution (give it in terms of both $\Delta\lambda$ and R)?
- What is the velocity resolution (in km/s)?

For this problem, assume the grating surface is normal to light from the collimator.

2. Slit positioning (10 points for 306, 20 points for 406)

Now, using the parameters from problem #1, think about the effect of moving a star from one edge of the slit to the other.

- If stars were truly point sources (unblurred by atmospheric seeing or telescope optics), what would be the velocity change in the star that you would observe if you moved the star from one edge of the slit to the other?
- Conceptually, how would you expect the velocity to change from one side of the slit to the other if the seeing was extremely good, say 0.5 arcsec FWHM? What if it was awful, say 5.0 arcsec FWHM? Make a sketch of how you would expect the velocity difference to change as the seeing varied in between those extremes, and explain your reasoning.

ASTR 406: Make a plot of the velocity difference as a function of FWHM for seeing that ranges from FWHM=0.1 arcsec (unrealistically good!) to 5 arcsec (utterly horrible). Make the simplifying assumption that in the spatial direction we are only extracting the spectrum centered on the star, so that you can treat the star's profile across the slit as a one dimensional gaussian. (Hint: you'll probably need to make use of the `scipy.special.erf()` function at some point in making this plot!)

3. Wavelength choices (5 points)

If you have a spectrograph (*different from the one in the previous problems*) where you can observe at either 4000Å or 8000Å with the same resolution (FWHM = 2 Angstroms), which of these two wavelength settings will give the better velocity accuracy all other things being equal?

4. Spectrograph design (15 points)

You designing a spectrograph for a 5m telescope working with a focal ratio of f/10. The collimator is a 6 inch collimator and the slit is 1 arcsec wide and projects to 30 microns (3pixels) on the detector. An astronomer asks you what spectral resolution will she will have with a 1200 line/mm grating at 5000Å. What do you tell her? Explain any assumptions you need to make.