AST 475/875 Exercise #4

Due F, October 15th

Imagine you are proposing to use the Keck I 10-m telescope and its HIRES high-resolution echelle spectrograph to carry out spectroscopy of a $V=16.15$ star having a temperature of 5500 K. A particular absorption line you are interested in lies at a wavelength of 4975 Å. Due to the celestial coordinates of the star and the particular nights you are allocated, you expect the typical airmass of your exposures to be 1.35. Assume that the point spread function of the star can be characterized by a Gaussian of FWHM 0.85 arcseconds. For now, let's assume that a single pixel of the HIRES CCD detector spans a wavelength increment at 4975 Å of 0.03 Å (in the future, you would want to know how to calculate this).

Go to www2.keck.hawaii.edu to access the PDF file of the Keck/HIRES user manual. Review this manual to find the efficiency/transmission of the cross-disperser, collimator mirror (which will you use? Blue or red?), and the KV370 filter that you will also utilize to keep out unwanted blue wavelengths. Assume that the dispersing grating has the same efficiency as the cross-disperser, and that the quantum efficiency of the HIRES CCD detector at 4975 Å is 80%, and that the reflectivity of the primary+secondary mirror(s) is 75%. You will be using the B5 decker/slit assembly to obtain a (slit-width dependent) spectral resolution (defined as $\lambda/\Delta\lambda$) of about 45,000.

A) Your task is to calculate the time required to obtain a (Poisson noise dominated) S/N of 40 per pixel at 4975 Å (assume this to be in the neighboring black bodyish continuum region just adjacent to the spectral line you're interested in) from first principles—i.e., using the definition of spectral flux density of $V=0.0$. Your estimate should account for: a) the flux for the given magnitude at a wavelength that is not the same as the mean of the V bandpass   b) slit losses due to the seeing profile of the star compared to the slit width c) extinction by the Earth's atmosphere and d) the relative efficiencies of the primary/secondary mirrors, cross-disperser, grating, collimator, blocking filter, and CCD.

B) Your pixel will contain 1600 photons from the source. If you are observing at full moon, estimate how many additional background photons this same pixel will contain (as a zeroth order assumption, assume that the lunar reflectance spectrum is that of the Sun, a 5780 K star). What is the percentage contamination of your source signal by moonlight?