Phys 214

Homework #1

S/N Calculations

Due by email or in class, Wednesday, April 10

A *R* = 20 star observed with LRIS (the Keck imaging spectrograph) at airmass X=1 produces 1890 detected photo-electrons per second. The *R*-band sky brightness at Mauna Kea is listed at the CFHT website as 20.3 mag/arcsec² during dark time. The LRIS red side camera pixel scale is 0.135 arcseconds/pixel, the readout noise is about 5e- and the inverse gain of the system is about 1.2 e-/DN. You can find all these numbers at
http://www.cfht.hawaii.edu/Instruments/ObservatoryManual/CFHT_ObservatoryManual_(Sec_2).html and
http://www2.keck.hawaii.edu/inst/lris/detectors.html

1. What is the rate of detected e-/pixel from the sky in the *R* band?

2. What is the rate of detected e- from a *R* = 26 magnitude star observed at an airmass of 1.2 assuming the extinction coefficient (k) in *R* is 0.1 mag/(unit airmass)?

3. Assume that you are measuring all of the light for the *R* = 26 magnitude star in an aperture with a radius of 7 pixels. At what exposure time does the measurement become sky dominated?

4. How does the S/N scale with seeing? (assume you scale the measuring radius linearly with FWHM of point sources)

5. What is the exposure time required to make an observation of this *R*=26 star with a S/N of 20?

6. What is the exposure time required to make an observation of the *R*=26 star with S/N=20 with HST's WFC3/UVIS in the filter that is the closest match to "*R*"? You'll have to look up both the central wavelength and the bandpass of the LRIS R filter, then look up the filters for WFC3/UVIS and choose the best match.

The purpose of this question is to demonstrate how much of a difference it makes to have a low sky background and difraction-limited images. Please use the WFC3/UVIS exposure time calculator at http://etc.stsci.edu/etc/input/wfc3uvis/imaging/
Choose the wide filter closest to R, choose a point source and the last option "Use a circular region containing 80 percent of the light," and for the spectral energy distribution, choose whatever HST Standard Star Spectra you'd like. Make sure you enter the correct magnitude for your target, and choose an average background.

If you did everything correctly, you will notice that the exposure time needed for a S/N=20 is much shorter than that needed for Keck (question 5), even though Keck is a much bigger telescope.

7. Go back to the ETC and change the size of the aperture to something bigger, like the default 0.4" or even larger. What happens to the exposure time? Why? Modify other parameters as well, and write up a summary of what you found.