ASTR469: Homework #5.

Due Feb. 17 at beginning of class.

1. You are trying to measure the flux from a 10th magnitude star at V-band. (2 points each)

   (a) Assuming you get 100 photons per second from the 10th magnitude star, how long would you have to integrate in the "bright source" limit (only source of noise is the source) to get a signal to noise ratio of 5?

   (b) Same question as b), but for a signal to noise ratio of 10.

   (c) If we are actually sky-noise dominated, why may we want to take short exposures instead of one long exposure?

2. For this question, we consider optical CCD-based measurements of the Triangulum galaxy (M33).

   Assume the telescope you're using to observe M33 expects to collect 5 photons per second from this target. The background contributes 2 photons per second. Your CCD is 1024×1024 pixels. The dark current is $dk = 10^{-8}$ electrons per pixel per second. The read noise is $r^2 = 10^{-5}$ electrons per pixel (note that this is r^2). The quantum efficiency is 50% at the observing wavelength.

   (a) (1 pt) Use SIMBAD or NED to find the visual (V-band) and blue (B-band) magnitude of the Triangulum galaxy.

   (b) (1 pt; throw-back study question) What is the color index of this galaxy?

   (c) (1 pt; throw-back study question) Based on the color index from the previous question, what class of star (OBAFGKM) dominates this galaxy (it will help to look at a CMD where the stellar classes are labelled)?

   (d) (2 pt) How many electrons are collected by the CCD per second, from the source? And from the background? (remember the quantum efficiency!)

   (e) (3 pt) Now assuming a QE of 100% but otherwise the same CCD parameters, plot the signal-to-noise ratio vs. exposure time (from 0 to 100s) for the following cases. Make sure you are explicit about what equation you are using to make these plots, and assume Gaussian statistics despite the low photon/s counts. Please attached printed versions of the plots you made:
   i) A source flux of 5 photons per second.
   ii) A source flux of 2 photons per second (same as the background!).
   iii) A source flux of 100 photons per second.

   (f) (1 pt) **Brief self-reflection:** Comment on the above plot; what is the implication of what you've plotted?

(g) (2 pt) For each of your plots/curves in b), how long do you have to integrate to get a S/N of 3?

(h) (2 pt) For only the 5 photons/s case, at what times does the read noise dominate?

(i) (2 pt) For only the 5 photons/s case, at what times does the dark current noise dominate?

3. (4 pt) What is the rest wavelength of the C92α emission line? And, what is the wavelength of that line if it is observed at a redshift of $z = 3$ (if you didn't get the line wavelength, just assume a wavelength for this second question)?

4. (1 pt each) It is worth noting that our telescopes are not stationary while we're observing. In a worst-case scenario, what redshift would be induced in an observation by the following effects? Assume you're observing an object at a sky position such that you see the largest induced relative motion between us and a stationary target. Note: in your solution, please explicitly box the relative velocity and the induced redshift you determine.

   (a) Rotation of Earth if you're observing from the equator (note, w.r.t the stars the Earth spins once per *Sidereal* day, and we observing from Earth's surface at a radius of $r = 6371\,\mathrm{km}$).

   (b) Rotation of Earth observing from the latitude of Morgantown (39.6°).

   (c) Orbit of Earth around the Sun (we go around once per year, at an orbital radius of $1.496 \times 10^8\,\mathrm{km}$).

   (d) Movement of Sun around the Galactic center (we take 230 million years and are at a radius of $\sim$8.3 kpc).