ASTR 306 - HW #1

*Note: Sometimes problems will have information missing. This is intentional, and meant to get you in the habit of using online sources to find the data you need. You **must** cite your sources, and the data **must** come from professional scientific sources (journal articles, observatory websites, data archives, NED, etc), not Wikipedia or amateur astronomy sources (ie SEDS, non-academic/professional websites, and the like).*

1. Star Coordinates (10 points)

Do this problem from first principles (just simple geometry and the definitions of RA and dec) without using online calculators or looking up seasonal visibilities, etc. Make sure to describe your work!

Star A has coordinates $(\alpha, \delta) = (44.58°, +21.5°)$. Star B has coordinates $(\alpha, \delta) = (88.2°, +19.6°)$. From Cleveland, what the altitude (in degrees) of Star A when it transits? About how long after Star A transits will Star B transit? What time of the year is the best for observing Star A?

Note: if you are doing this using equations of spherical trigonometry, you have made the question much much more complicated than it is….

For the rest of the problems on the HW set, when needed you should use skycalc to help with calculating sky coordinates, airmasses etc.

2. Galaxy Coordinates and Distances (10 points)

What are the J2000 coordinates of the galaxies M81 and M82? What time of the year are they best visible? How far apart are these two galaxies on the sky? At their distance, what does this separation translate to in terms of a physical (projected) separation?

3. Observing the Antennae (10 points)

We want to observe the galaxy pair NGC 4038/4039 ("The Antennae Galaxies") using the 4m telescope at Kitt Peak (KPNO). Use the online skycalc site to work out the best time of the year (to within a few weeks) to observe it. At that time, how long is it above 1.5 airmasses each night. How does your answer change if we used the 4m telescope at Cerro Tololo instead? Make sure to explain why there is a difference!

(Important: when astronomers say an object is "above 1.5 airmasses" they mean "higher in the sky than 1.5 airmasses, i.e., $\sec z < 1.5$).

4. Building an Observing Sample (10 points)

I am using the KPNO 4-m telescope to do a spectroscopic survey of peculiar A stars. If each star takes two hours to observe, and I don't want to observe when stars are below 1.5 airmasses, what is the allowed declination range for my sample of stars? *Think about both the northern and southern declination limits.*

5. Extinction and Magnitudes (10 points)

The file http://burro.case.edu/Academics/Astr306/HW/HW1/stanphot.dat has several observations of a bunch of standard stars taken at different airmasses. The datafile gives the star name, the true V magnitude and $B - V$ color of the star, the airmass of the observation ("secz") and the (uncalibrated) instrumental magnitudes in B and V filters. In this case, the instrumental magnitudes are defined as

$$m_{inst} = -2.5 \log I + 25$$

where I is the number of counts on the detector from the star and is proportional to the total flux (f) received from the star. Using this data, adopt a model for the photometric solution in each filter that looks like this:

$$m_{inst} - m_{true} = KX + ZP$$

And then work out the values for the extinction term K and photometric zeropoint ZP in each filter. Make sure to also give their uncertainties! Show a plot of the data, with your fits overplotted. Explain why one filter has a higher value of K than the other.

Now, think about the bright star Capella, which has a true magnitude and color $m_V = +0.08$ and $B - V = 0.8$. Use your fitted extinction terms (K_B and K_V) to answer the following:

- How much brighter is Capella when observed at the zenith compared to at an airmass of X=3? In other words, if the star has an observed flux f, what is $f_{zenith}/f_{X=3}$? Do this for both B and V magnitudes.
- If you were observing Capella from space, how much brighter would it be compared to its zenith brightness on Earth (f_{space}/f_{zenith})? Again, do this for both B and V magnitudes.

6. Plate Scale and CCDs (10 points; courtesy Paul Harding)

I want to get photometry for stars in the globular cluster M13 (which has an angular diameter of about 10 arcmin) using the prime focus camera on a new telescope at Kitt Peak Observatory. When I turn up for my observing run, I am asked what CCD I wish to use. I don't want to let on that I have not read the observers manual, so a quick look at the telescope tells me the distance from the primary mirror to the focal plane is 40 feet. I have three CCDs to choose from:

- CCD A: 3000x3000 pixels; each pixel is 9x9 microns in size,
- CCD B: 2048x2048 pixels; each pixel is 24x24 microns, and
- CCD C: 8192x8192 pixels; each pixel is 6x6 microns.

I want to fit the entire globular cluster onto the field of view of the CCD, and I also know that the typical seeing at KPNO is about 1 arcsec, so there is no point having pixels with an angular scale that is much smaller than that. Which of these three CCDs would you pick? Explain your reasoning.

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7. Scheduling Observing Runs (10 points)

You want to observe the galaxy M101 this spring from Kitt Peak. You need to be observing it at no more than 1.5 airmasses, you need the Moon down, and you want to be able to observe at least 4 hours per night. In March, April, and May, what are the range of usable dates?

8. Coordinate Epochs (10 points)

You are observing the Crab Nebula tonight using using the Gemini North Observatory's imaging spectrograph GMOS. Looking at some old papers, you see them listing the Crab Nebula as having a B1950 equatorial coordinate of

$$(RA, \delta)_{B1950} = (05{:}31{:}31.4, +21{:}58{:}54)$$

The Gemini control system wants coordinates in the J2000 system, not B1950. Use astropy's SkyCoord functionality to convert the B1950 coordinates to J2000.

If you had mistakenly input the B1950 coordinate into the telescope control system, how badly (in arcminutes) would you be mis-pointing the telescope? Calculate the mispoint by hand, using the cartesian approximation, and then check your work by using SkyCoord functions to calculate it more accurately.

With that kind of mis-pointing, would you even see the Crab in your image?