ASTR 306/406 - HW #1

Note: Many times 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 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? *Do this problem from first principles (ie geometry and the definitions of RA and dec) without using online calculators or looking up coordinates, etc. Make sure to describe your work!*

For the rest of the problems, it's okay to use online calculators when necessary. In particular, you might find the NASA Extragalactic Database useful, as well as Skycalc.

2. When I observe, to minimize problems with the atmosphere, I won't observe my objects at airmasses greater than 1.5. How low in altitude is this? I will admit, though, having been desperate enough to chase something down to 2 airmasses. How low (in altitude) is that? Now go outside and point to where objects transiting at an airmass of 1.5 and 2.0 would be, both in altitude and azimuth. (Yes, really. Do this. If you don't, I have ways of knowing you didn't, and I'll be crabby at you.)

3. The file http://burro.case.edu/Academics/Astr306/HW/HW1/stanphot.dat has several observations of one star (the Landolt standard star PG0039+049; $m_V = 12.88, B - V = -0.02$), taken at different airmasses. The datafile gives the airmass of the observation and the instrumental magnitudes in B and V filters, respectively. From the data, work out the values for the airmass 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.

Then, using your fitted airmass terms, make a plot showing how much the observed color of a star changes as it moves from zenith down to an airmass of 3 (ignore the zeropoint difference here; assume that you've already corrected for this). In terms of flux (not magnitudes) how much fainter is the star at an airmass of 3 than at 1 airmass? If there were no atmosphere at all, how much brighter would the star be compared to its sec(z)=1 brightness?

4. We want to observe the galaxy pair NGC 4038/4039 using the 4m telescope at Kitt Peak (KPNO). When is the best time of the year (to within a few weeks) to observe it, and 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!

5. 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?

6. What is the Crab Nebula's B1950 equatorial coordinate (in sexagesimal notation)? Its J2000 coordinate? Its coordinate today? You're observing this fall using the Gemini Observatory's imaging spectrograph GMOS. If you mistakenly pointed the telescope at the Crab tonight using its B1950 coordinate, how far off would your pointing be? Would you see it in your image?

Change the "pointed tonight" to "pointed with a telescope using J2000 coordinates".

Note: to transform coordinates to arbitrary equinox dates, you can use either:

- *Chandra webtool https://cxc.harvard.edu/toolkit/precess.jsp*
- *Astropy: https://docs.astropy.org/en/stable/coordinates/transforming.html*

7. I am using the KPNO 4m to do a spectroscopic survey of Ap stars. If each observation takes an hour, and I don't want to observe below 1.5 airmasses, what is the declination limit of my sample? *Think about both the northern and southern declination limits.*

ASTR 406 extras:

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

9. Use astropy's Coordinate functionality (explained here) to work out how fast the small angle Cartesian assumption for calculating angular separations breaks down. Here is a dataset of SDSS stars within a few degrees of the spiral galaxy M101. Work out the angular distance of each star from the center of M101, using both the small angle approximation and the true angular distance via astropy. Make a plot of the log of the difference between the two methods (y-axis) versus the true separation (x-axis). If you wanted to keep your calculated distances accurate to 1 arcsecond or better, at what point should you not be using the small angle approximation?

Make sure the datafile has SDSS stars close to M101