Exercise set nine

1 Analysis: Motion of the planets

Materials

data from your planet observations, ruler, star chart of region with RA and Dec

Goals

You should have enough data to plot the position of Mars and Saturn on several different nights over the course of the semester. The goal of this analysis is to measure the motion of each planet against the background stars.

If you are missing some of the data you need, just do as much of the following procedure as you can, and explain what additional observations you should have taken.

Instructions

Individual night plots

1. Make a separate chart for each night showing the positions of each planet (see "General plotting procedures" below).
2. Label each chart with the date of the observations.
3. Measure the separation between the planets as you have plotted them on each chart, and convert that into degrees. Make sure to estimate your uncertainty. I'm looking for something like this: *Separation between Mars and Saturn* $= 31^\circ \pm 8^\circ$.
4. Compare this to the separation you measured in the sky. Do they agree to within your uncertainty?

Time series plot

1. Make a plot with all of the best-estimate positions indicated and labeled by date.
2. Can you say with any certainty if any of the planets moved over the course of your observations?
3. Calculate the apparent speed of each planet (*in hours of right ascension per day*) between each consecutive pair of observations. Movement to the East (increasing RA) should be positive, movement to the West should be negative.
4. Calculate the average speed over the course of all of the observations. If can't tell whether the planet moved, then put an upper limit on the speed. In other words, what is the maximum speed with which the planet could have moved and still have appeared to be stationary with your observations.
5. Ask me for a plot of the actual positions, and compare it with your plot. List any important differences, and what factors might have contributed to your error.

General plotting procedures

This is the procedure for plotting the position of a planet using measured angular distances between the planet and three or more stars of known position:

If you haven't already, figure out the angular scale of the chart: measure the separation x between lines of declination in cm. If the lines of declination are spaced d degrees apart, then your scale is $s = d/x$ degrees per centimeter. Now, if you want to convert a measurement of d degrees into cm on the chart, you would use $x = d/s$. If you want to convert a measurement of x cm on the chart into degrees you would use $d = xs$.

Convert your measurements of star-planet angular separations into chart units (cm). Use some paper to make a makeshift compass and trace an arc of the appropriate radius around each star. Ideally all of your circles will intersect almost at a single point. Draw a point to indicate your best estimate of the location of the planet. *Also draw a shape around your point to indicate your uncertainty in the position, i.e. the extended region where you think the planet might actually be, given the error in your measurements.*