PHYS 310 – Homework 5
Spring 2016

The moon Callisto travels a nearly circular orbit around Jupiter. From earth, we see the orbit roughly edge-on. The moon appears to travel back and forth across or behind the face of Jupiter.

In ASTR 101, students take images of Jupiter and its moons on successive clear nights. We can use these data to determine the orbital radius and period of the moon Callisto. We can also determine the mass of Jupiter.

The file 'callistoData.txt' contains columns (1) time of observation (in units of solar days), (2) distance between Callisto and Jupiter in units of Jupiter diameters (1 Jupiter diameter = 142,984 km at the equator), and (3) uncertainty of the distance in Jupiter diameters. Column 3 is an estimate; we find that students can measure this distance to an accuracy of about 0.2 Jupiter diameters. The sign convention for distances is negative to the left side of Jupiter, positive on the right side, as viewed on the final images.

Your job is to modify the 'fitDecayingSineCurve.py' script to fit the period (*P*) and orbital radius (*R*) for Callisto. The third parameter, *t0*, is a phase term that gives the time of a 'rising zero-crossing,' i.e., when Callisto is behind or in front of Jupiter.

The model is,

$$y = R \sin\left(2\pi(t - t0)/P\right).$$

Assuming the parameters are stored in an array *p* in the order *p* = [Radius, Period, Phase], the Pythonic expression is,

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model = p[0] * sin(2*pi*(t – p[1])/p[2]).
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Analyze the results of the MCMC fit and report them in a sensible way that impresses your instructor. Is there any evidence for covariant parameters? Were there any incorrect assumptions, or systematic issues with the data?

Finally, use the properties of circular orbits and Newton's Law of Universal Gravitation to calculate the mass of Jupiter based on these data assuming the mass of Callisto is negligible compared to Jupiter (*Hint*: look up how to deduce central mass using Newton's generalization of Kepler's 3rd Law). Be sure to propagate uncertainties *correctly.* If there are covariant parameters, you won't be able to propagate uncertainties using conventional methods. (*Hint*: Calculate an array of masses, one for each value of radius and period from the MCMC fit, and statistically analyze that array.)

You will hand in:
(1) On paper, a report of your analysis with appropriate plots.
(2) Your python script, which you will upload to Moodle. Be sure to document the script so I can follow it.