AST 381: Planetary Astrophysics

Homework #4

The assignment here is to run an MCMC fit for an RV planet's orbit. This should be a Metropolis-Hastings fitter with a Gibbs sampler, which is what we talked about in class. No, you are not allowed to just send the function to emcee and let a miracle occur. You should code up the fitting routine using your language of choice.

To simplify matters, we're going to use a Hot Jupiter with a circular orbit, and we aren't going to try fitting transit data or anything silly like that. This means that while you can use your orbit predictor code if you want, it's probably just easier to do this analytically using a sine curve. To be specific...

A) You should plan to fit three parameters: orbital period, Msin(i), and a time zero point. (Note that for a circular orbit, longitude of periapse is formally undefined, so I suggest defining the time zero point to be when the planet is crossing in front of the star with zero radial velocity.)

B) Don't worry about multiple walkers or anything like that. Do worry about making sure you discard early steps before burn-in.

C) You should track the acceptance rate on proposed jumps for each parameter. Recall from our discussion in class that you don't want a value that's too high (or it takes a long time to mix) or too low (wasting a lot of computation power on failed jumps). Aim for 20 to 40 percent, and adjust your jump sizes accordingly.

D) You should report the median value for each parameter, as well as the range encompassing the central 68% (i.e., a 1-ish sigma confidence interval).

E) You also should produce contour plots of the 2D posterior for all combinations of parameters: Msin(i) vs period, Msin(i) vs time zero point, and period versus time zero point. Have the contours enclose useful amounts of the posterior (i.e., 50/90/99/99.9 percent, or 68/95/99.7 percent).

F) You should produce a phased RV curve, showing the data points (with error bars) and your best-fit solution. Cautionary note: Pay attention to what's going on around phase of zero, and decide if that specific data should be constraining your model.

G) In addition to the things in the previous 4 bullet points, which should be reported in a concise summary, you should upload your code to github.

The system that we'll be using is HD 209458. Luckily Stefano has a set of RVs from Keck online that we can adopt:

https://github.com/stefano-meschiari/Systemic2/blob/master/datafiles/HD209458_3_KECK.vels

Feel free to go look up the actual system parameters, or pretty much anything else you think you need. No discussion amongst yourselves though.