Problem Set #4

Due Monday, October 23 at 5pm

Please indicate the time spent on the assignment and list any collaborators. You can submit the assignment by emailing a single PDF to dressing@berkeley.edu or by placing a hard copy in my mailbox or under my door (Campbell 605E).

1. Final Project Preparation

The abstract for your final project is due Friday, October 27 at 5pm. The following questions should help you prepare for that deadline.

a. Describe your final project in 3-5 sentences.

b. How do you plan to approach the project? Include a timeline with major project deadlines and intermediate steps (e.g., read papers about question X by DATE 1, write code to accomplish goal Y by DATE 2, draft section Z by DATE 3).

c. List three things you've already learned about your final project topic.

d. List two lingering questions about your final paper topic.

e. Do you have any concerns or questions about the final project?

2. Guest Lectures

a. Write two things you learned from Monday's class with Megan Ansdell. At least one of your responses should be related to planets.

b. Draw a schematic of an adaptive optics (AO) system. What is the purpose of AO and why are astronomers so interested in improving their AO systems?

3.* For Experienced Programmers: *The Return of the Mystery Planet

You've continued monitoring the star that displayed a single transit in Problem Set #3. After a frustrating streak of bad weather, you finally saw additional transits. Download the transit data from the course website and follow the steps below to try to learn more about the mystery planet. The columns in the file are time (in days), relative flux (normalized to 1 when the planet is not transiting), and error (in the same normalized units as flux). The host star is a mid-M dwarf with $M_\star = 0.157\,\mathrm{M}_\odot$, $R_\star = 0.211\,\mathrm{R}_\odot$, and $T_{\text{eff}} = 3026$ K.

a. Assuming that a planet is in a circular orbit and transits when orbital phase = 0, at which orbital phases should the radial velocity signal be minimized and maximized? Draw a diagram to explain your answer. (This result is true in general, not just for the mystery planet.)

b. Download your new transit data from the course website and plot the brightness of the star versus time. Include error bars on your data points.

c. Looking by eye, what is the apparent orbital period of the planet? How does that compare to value you estimated on Problem Set #3?

d. Phase-fold the data to the orbital period you found in part (b) and produce a phase-folded plot of the transits.

e. What is the apparent transit depth?

f. Use the stellar radius to convert your answer to part (e) into a planet radius in Earth radii.

g. Phase-fold the RVs from Problem Set #3 to your revised estimate for the orbital period.

h. What is the observed radial velocity semi-amplitude?

i. Use the stellar mass to convert your answer to part (h) into a planet mass in Earth masses.

j. What is the bulk density of the planet?

k. Which of the compositional models from Problem Set #3 are more consistent with the measured mass and radius? Is your answer more or less realistic than your answer on Problem Set #3?

l. *Optional Challenge Version:* Rather than inspecting the light curve by eye, use the tools you developed for the Challenge Problems in Problem Set #2 to fit the transit data to determine the properties of the planet and answer questions (c) - (g). You may want to use Laura Kreidberg's `BATMAN` package and Daniel Foreman-Mackey's `emcee` package. Then use B.J. Fulton and Erik Petigura's `RadVel` package and your code from Problem Set #3 to estimate the mass of the planet and answer questions (h) - (k).

4. **Programming-Free Alternative to Problem 3:** ***Highlights from the Literature***

Select one paper from each category and summarize the motivation, methodology, results, and conclusions. Include a representative figure from each paper and write a few sentences explaining how the figure connects to the rest of the paper. Your full answer for each paper should be 1–2 paragraphs. You may summarize up to three additional papers (6 papers total) for extra credit.

a. Pick 1: Batygin et al. 2016; Moriarty & Ballard 2016

b. Pick 1: Dressing & Charbonneau 2015; Fulton et al. 2017

c. Pick 1: Inamdar & Schlichting 2016; Lopez & Rice 2016; Owen & Wu 2017