Project 3 - Transiting Exoplanets

Part 1.

We want to explore again the statistics of the exoplanets detected thus far using the NASA Exoplanet Archive `https://exoplanetarchive.ipac.caltech.edu`. This time we focus on transiting exoplanets.

1. Plot the mass of detected exoplanets as a function of orbital semi-major axis, like we did in week 1, and this time highlight the planets detected with the transit method. Try now plotting the planet radius (in units Earth radii) versus period. Can you see any structures in the data?

2. We saw in previous exercises how the RV method allows us to measure the planet mass. The transit method instead allows us to measure the planet radius. Produce a histogram of the radius distribution for transiting planets (in units of Earth radii) for planets between $0 - 20$ Earth radii. Can you describe the kind of populations sampled by the peaks? Try to use logarithmic binning.

3. Identify planet WASP-39 b in the dataset. What could be some interesting measurements that can be done on this system?

Part 2.

Let's explore exoplanet transits! We will use the python package `batman` that models transit light curves (docs `https://lkreidberg.github.io/batman/docs/html/index.html`). In the provided notebook you can find an example of initialised parameters and a light curve produced.

1. Explore how the shape of the lightcurve varies with the planet parameters. Can you explain how the lightcurve changes for different radii, periods, and inclinations?

2. The Early Release Science (ERS) programs on the James Webb Space Telescope (JWST) were some of the first science data collected by the mission in summer 2022. The data were public immediately and included an observation of WASP-39 b in transmission with the various observing modes of JWST. We are going to look at some processed data from Rustamkulov et al 2022 using the NIRSpec/PRISM mode (see more details for this instrument here `https://jwst-docs.stsci.edu/jwst-near-infrared-spectrograph`.) The python notebook loads the data as a function of detector column (corresponding to wavelength) and time. We have visualised the image for you with the imshow() function. What features can you see in the signal displayed, and why? Can you see variations in the dark stripe. What causes these variations?

3. Collapse the data along the wavelength axis in order to create a white light curve. Can you see the transit clearly in the collapsed data? Try

excluding the noisy regions at the edges of the wavelength range in the image. Now can you see the transit clearly? What about the baseline, are there any systematic trends in time? Any systematic noise in time will affect the transit fit (a linear or quadratic correction is usually enough to correct for it).

4. Estimate the radius of WASP-39b from the lightcurve.

5. **(Bonus)** Calculate the transit depth of WASP-39b as a function of wavelength.

Note *To receive feedback on your project work please upload it as a PDF-file to the moodle-course. In case you have any questions, please contact Komal Bali (kobali@phys.ethz.ch), Janina Hansen (jahansen@ethz.ch), and Sean Jordan (jordans@ethz.ch).*