Available Projects: Academic Year 2023 - 2024
PI: J. Becker

There are three types of projects in this document - analytical projects, numerical projects, and data-driven projects. Here's a short description of the kind of work flow that each of those project types entail:

- **Analytical Projects.** These projects use equations to answer questions about planetary evolution and dynamics. The workflow for these types of projects includes a lot of reading and a lot of solving and manipulating equations. The tools that you will use for these projects include mathematica, pen and paper equations, and python. These projects would be well-suited for someone who enjoys math.
- **Numerical Projects.** These projects use computers to solve problems that are too complex to solve by hand. The workflow for these types of projects will include learning to code and use specific packages that have been written to solve problems in exoplanets. The tools you will use for these projects include python (packages: rebound/reboundx, pandas, numpy, matplotlib) or other codes such as VPLanet. These projects would be well suited for someone who enjoys coding and using computers to solve problems.
- **Data-driven Projects.** These projects involve using data to answer questions. Sometimes, the workflow will include finding data and results that have already been published, and then using them to answer new questions, and sometimes the workflow will involve getting new data and using it to answer questions. These projects are well suited for someone who is interested in learning a wide array of new skills.
- **Reading Projects.** These projects involve searching for the answers to questions in the published astronomical literature. You will be taking a single topic and reading multiple papers about it, and you may write a summary at the end of what you have learned (with citations). These are good projects for someone who has not done any research before and is looking to gain a familiarity with what astronomical research looks like.

Analytical Projects

1. *Transition disks and planet migratio*n. In this project, you would be looking at how the exact prescription of disk dissipation of the disk will affect a Jupiter-sized planet with nearby companions, both in terms of their orbital properties and (possibly) their atmospheric properties and envelope fraction.
2. *The Effect of Migration on the Structure and Chemistry of Planets.* The project will assess the surface heat flux of various migrating planets and determine how the planet's structure and chemistry may change due to tidal and radiative heat flux. The project will identify a population of planets expected to experience long-scale migration. The project will then use theoretical models to calculate the surface heat flux of these planets. The project will use the results of these calculations and measurements to determine how the planets' structure and chemistry may change as they migrate. This project is open-ended and will require solving differential equations and managing large data sets.

Numerical Projects

1. *Survival of oceans during planet migration.* In this project, you would use VPLanet to model ocean survival during planetary migration, with a particular interest towards moons that have been lost from Jupiter-like planets and scattered into short-period orbits. This is an exploratory project and may not lead to a publication.
2. *Formation of planets interior to hot Jupiters.* In this project, you would use numerical simulations to measure planet-building in a disk with a limited mass (limited due to the presence of a hot Jupiter slightly exterior). Making a variety of assumptions about the properties of the Jupiter-size planet, you will model the maximum mass of the planet that could form interior to its orbit, and then link those predictions to the observational sample. This is a project that might lead to a publication.

Data-driven Projects

1. Ultra-short period planets (USPs) are planets that orbit their host stars in less than 1 day. In this project, you would look at the population of USP planets and determine their likely interior structures. This will be done by studying the planets' mass, radius, temperature, and compiling a list of other existing constraints from the literature. The student would then compare the interior structures of USPs to those of other exoplanets with longer orbital periods. This is an exploratory project that could go in several directions.

Reading Projects

1. *Outgassing on solar system planets and exoplanets*. In this reading project, you will review the current state of the literature on how planets exchange gas between their mantles and their atmospheres. Your goal will be to understand what is understood about outgassing in the solar system, and then identify to what extent those concepts have been applied to exoplanets.
2. *Building a database of resonant systems.* In this project, you will learn about orbital resonance and read through papers about resonant systems. Your final goal will be to make a list of all known resonant systems, along with any particularly notable properties those systems may have.