Kaitlyn Le

Python Decal

May 2, 2025

Analyzing Orbital Properties of KOI Systems

Introduction

In this final project, I analyzed the relationship between orbital properties among the KOI planetary systems. The goal of this project was to discover trends with the relationships between planetary mass, radius, and orbital period by applying statistical methods, model fitting, and residual analysis. I explored the mass-period and radius-period relationships while utilizing power-law models to fit the data.

Methods

Attaining the Data and Cleaning/Filtering

The data source that I will be utilizing to complete this project is from the NASA Exoplanet Archive's Planetary Composite Data Base https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbls&config=PSCompPars. The key libraries used were the following: pandas, numpy, matplotlib, seaborn, scipy.optimize, and plotly. For mass analysis, planets with masses between 1 and 100 Earth masses were utilized, while for radius, all planets with positive radii and periods were included.

For model fitting, the power law function was used where y = C(x^k), where y represented the mass or radius, x was the orbital period, and C and k were constants that were determined by the fit line. I also used scipy.optimize.curve_fit to fit the power-law models to the data.

Residual analysis was also used to assess the model fit quality. The residual plots assisted in revealing any deviations from the model. The residuals should scatter around zero.

The concepts applied were the power-law scaling, Kepler's third law, residual analysis, and log-log transformations. The power-law scaling is used for calling planetary scharastics with orbital properties while Kepler's Third Law shows the period dependence. Residual analusis was used to evaluate model adequacy and log-log transformations were significant for inptertation of power-law behavior.

Results

For mass-period relationship, I initially had a flat line as my best fit line because I did not properly filter the dataset. After filtering, there was a trend that emerged between mass and period where it seemed to be an inverse relationship. The trend showed that as period increased, the planetary mass would decrease.

For radius–period relationship, there was a weak but positive correlation. Larger planets tended to have longer periods and that the best-fit line parameters suggested a gentle scaling. The residuals indicated minor but sufficient deviations.

Learning Process

Throughout working on this project, I learned the significance of data cleaning and filtering, especially with datasets that have outliers or inconsistencies. I also learned a lot about fitting models and applying them to data sets, and residual analysis to accurately measure the efficiency of the best fit line.

CONCLUSION

Significance of the Project

This project can provide insight into the structure and principles of planetary systems outside of the Solar System. By exploring the trends between mass, radius, and period, we can improve our understanding of planetary formation. Data cleaning, model fitting, and resitudal analysis are also important for astrophysics as learning to utilize them for noisy data is important for creating conclusions about our universe.

By analyzing the orbital properties of the KOI planetary systems, I showed that there are significant physical relationships between mass, radius, and orbital period. This can be achieved through data handling (such as cleaning and filtering), model fitting, and statistical analysis. Power-law models showed that they are capable of displaying these trends, and the residual analysis confirmed the model quality.