Transit of HD189733b

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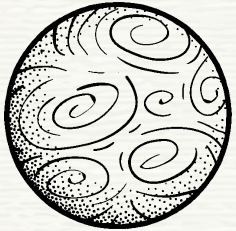

Overview

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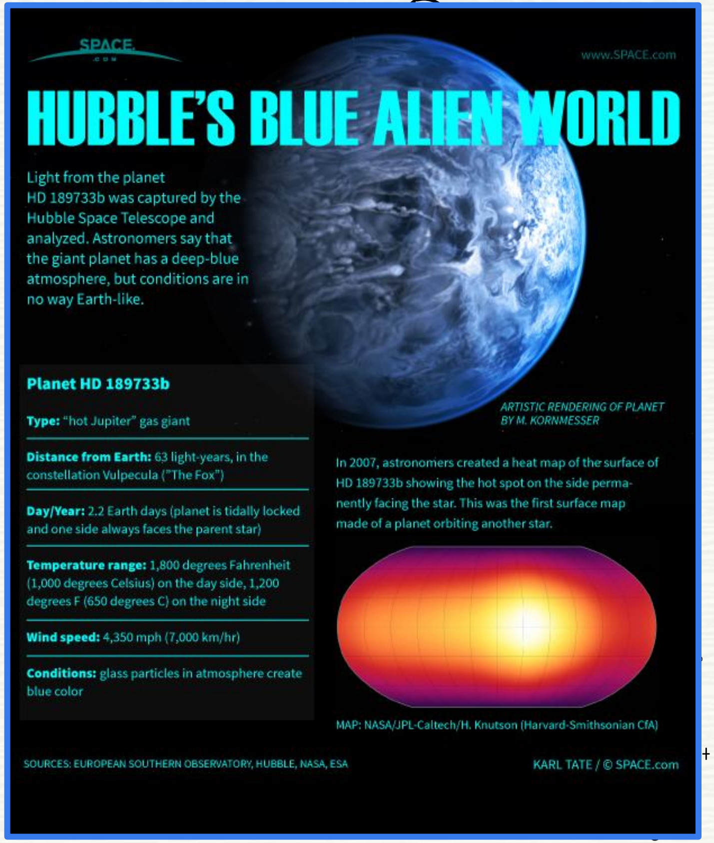
Introduction

What are exoplanets?

Exoplanets, also known as extrasolar planets, are planets that revolve around an astronomical object, such as a star, that is not our Sun.



How do we detect exoplanets? There are many methods, including. . .

Radial Velocity

This method calculates the wobble caused by a planet when it orbits a star, which affects the star's light spectrum.

Direct Imaging

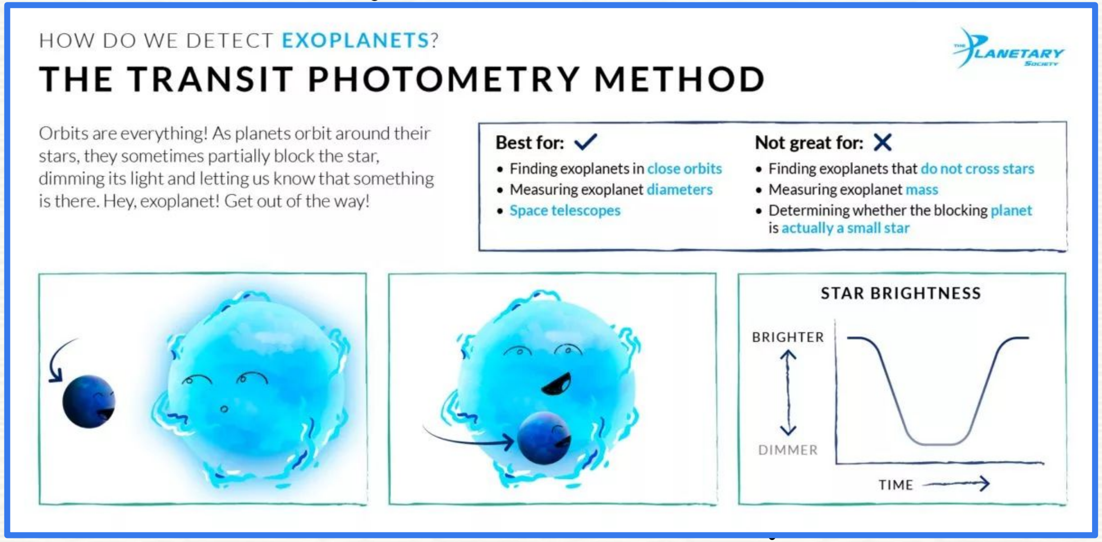
With this method, you are actually looking at the exoplanet, especially those with larger orbits.

Gravitational Microlensing

For this method, we actually need more than one star. When a star passes in front of another star, it acts as a lens to make it brighter. If there's an exoplanet, it acts as a second lens, which makes its star even brighter.

The transit method!

As an exoplanet passes in front of a star, the brightness of the star dims (known as flux). With this method, we are able to calculate the planet’s size and orbital period as well as its atmospheric composition.



Motivation

What is the point of this?

- ★ One of the main reason we study exoplanets is to locate potentially habitable worlds outside our solar system.
  - By figuring out the atmospheric composition, size and how close the exoplanet is to its star, we are able to determine which categories of life that it fulfills according to what we know about Earth.
  - Additionally, astronomers need to consider the possibility that Earth-life isn’t the only kind of life to exist and therefore, need to think outside of the box when determining potentially habitable planets.
- ★ By continuing to research exoplanets, we are also able to learn more about how the universe works and how are own solar system may have formed.
  - Even though we weren’t present at the formation of our on system there is a lot we can infer just by watching and studying the formation of exoplanets and their planetary systems.
- ★ Overall, there is much we have learned and even more that we have yet to learn about exoplanets and our own universe.
- ★ **The goal of this project is to use transit data of a specific exoplanet and find a best-fit model for its transit to calculate its size and orbital period.**

Methods

The process

- ★ Using transit data from Winn et. al (2007), I created a box model and trapezoid model that best fit the data and compared them.
- ★ This was done by fitting the parameters, time, center-time, duration, depth and change in flux, to the data.
  - Time (t): array of times
  - Center-time: defines the center of the model.
  - Duration: how wide the model is
  - Depth: how deep the model is
  - ΔFlux: determines how the model shifts up and down
- ★ With these models, we are able to calculate the size of the planet and orbital period.
  - This can tell us a lot about the planet and the star that it orbits.
- ★ Then, I determined the chi-square of each model, which shows how well each model fits the data.
  - The closer to 1 it is, the better!

Equations

Radius

$$\frac{\pi R_{Pl}^2}{\pi R_{Star}^2} = \frac{R_{Pl}^2}{R_{Star}^2}$$

Radius (R) = 12.5 R_E

Note: This equation represents the depth of the transit, but it can be altered to find the radius of the exoplanet.

Orbital Period

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

Orbital Period (T) = 2.2 days

Orbital Velocity

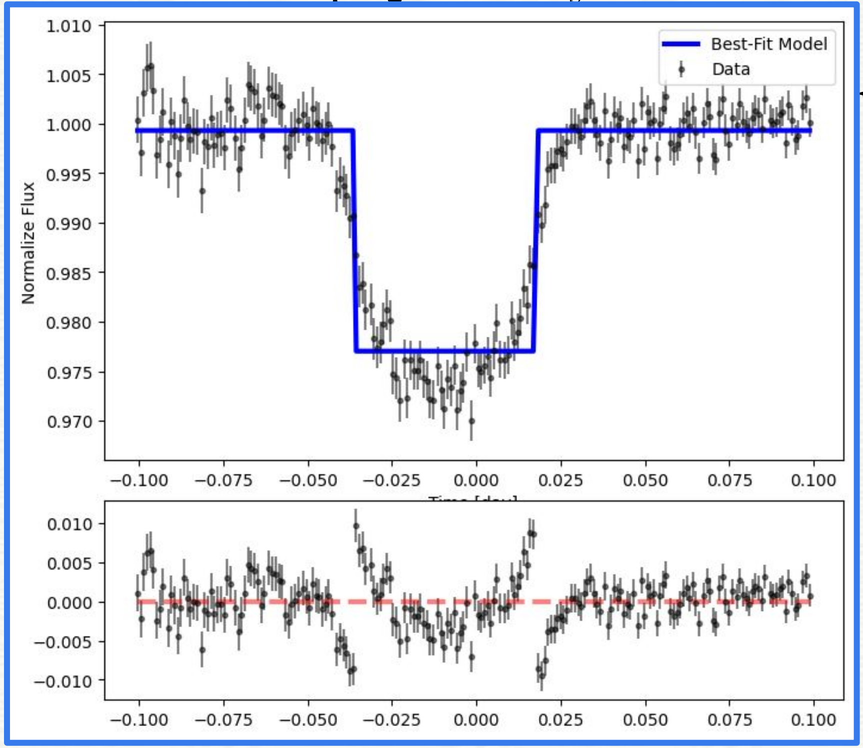
$$v_{orbital} = \sqrt{\frac{Gm}{R}}$$

Orbital Velocity (V) = 152 km/s

Results

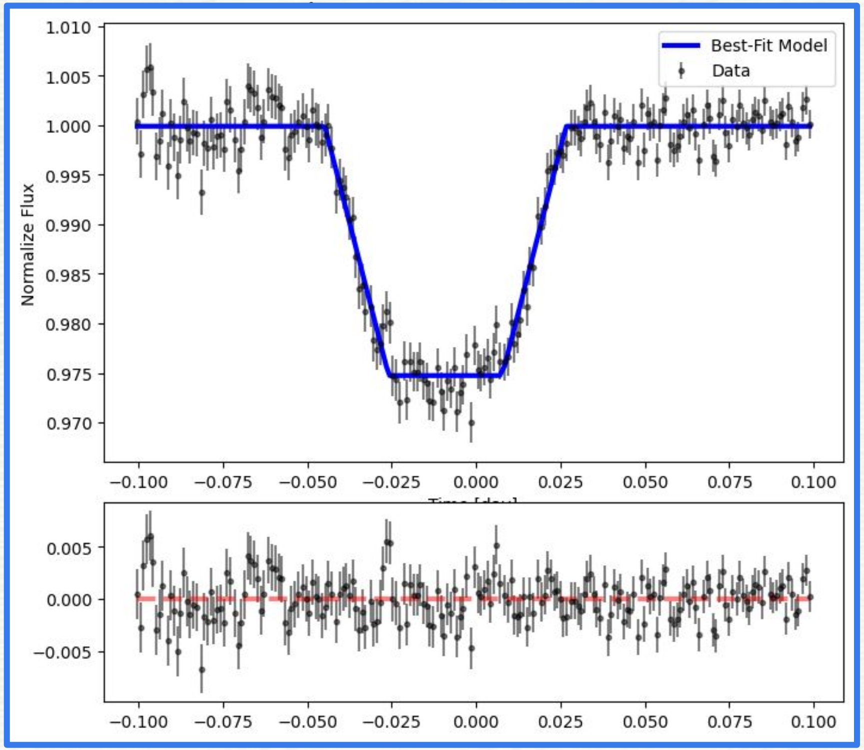
The box model

- ★ In order to calculate the shape of the orbit, we need a model that fits the transit data. One of the simplest is the box model, as seen here.
- ★ Although this model works, it is not the best. It doesn't completely follow the trend of the data due to it being so rigid.
- ★ Additionally, it doesn't pass the chi-squared test.
  - Chi = 2.58666392978909



The trapezoid model

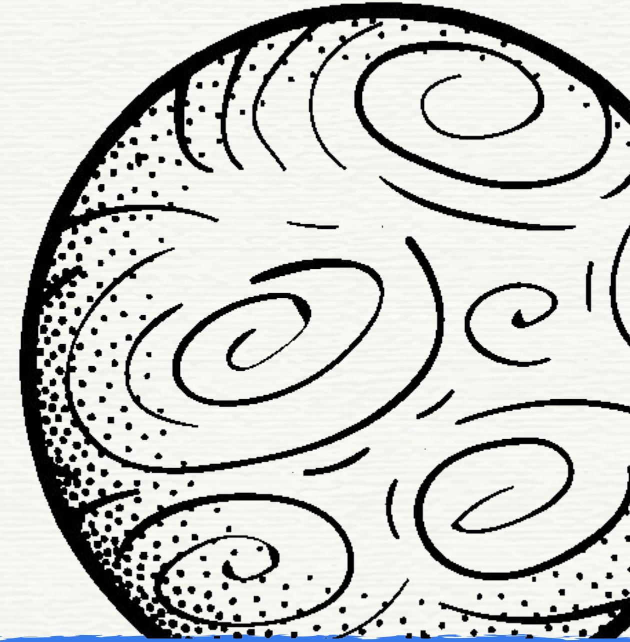
- ★ Since the box model didn't work as well, finding the best-fit model has become more complicated.
- ★ Now, we will look at the trapezoid model. This model better fits the data, visually.
- ★ To determine how much of a better fit it is than the box model, we must consider the chi-squared.
    - ○ Chi = 1.1139302477017554



Conclusion

The future

- ★ Despite the fact that both models would work, neither is the best-fit for this data. Their chi-squares are much too large.
- ★ Due to this, future steps that I need to take is to find a better model to fit the data.
- ★ Additionally, I could look at different data of the same exoplanet, since there are other sets out there.
    - ○ Maybe 202 data points is not enough and more are needed to achieve this project’s goal.



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