Build-A-Planet

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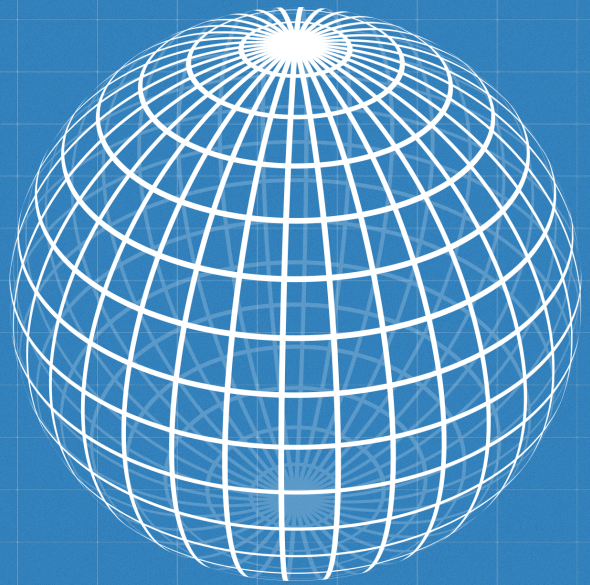


Introduction

Goal: To investigate the internal structure and composition of Trappist-1f using its measured mass and radius, and to simulate models with an academic software call ExoPlex.

Why Trappist-1f?

- It is located within the habitable zone of its host star, Trappist-1, which is a cool red dwarf.
- It is a well-known rocky planet with mass and radius measurements.

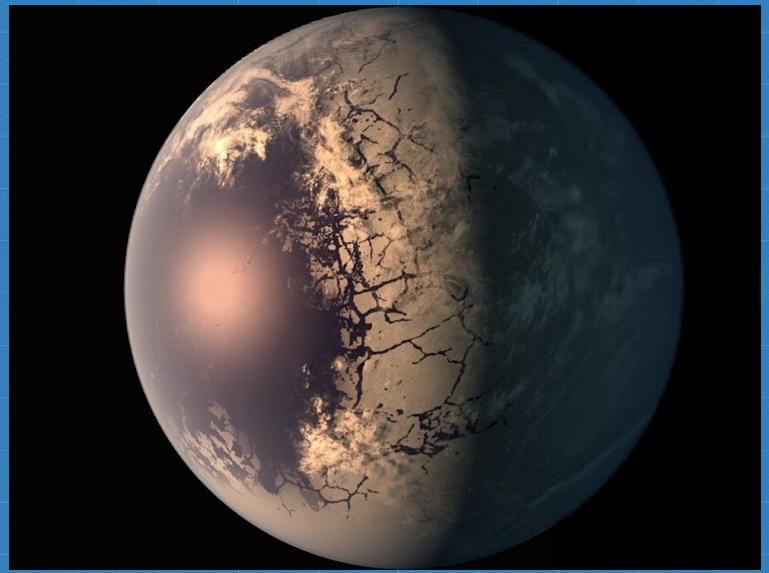
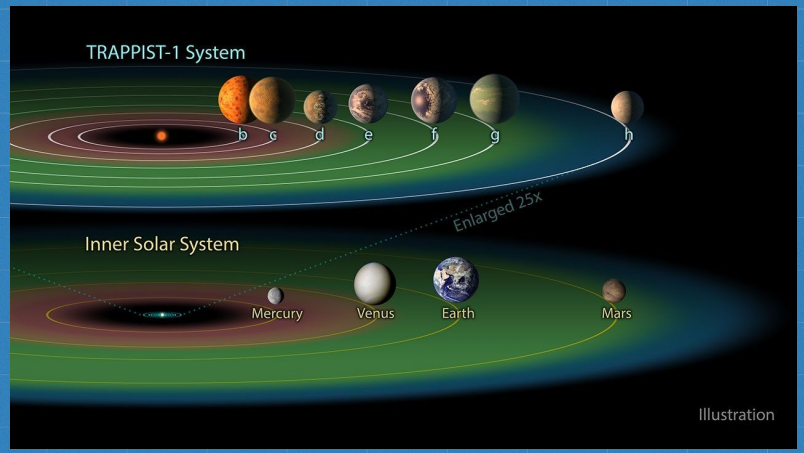


Image Source: https://science.nasa.gov/exoplanet-catalog/trappist-1-f/

Why Study Trappist-1f?



- Trappist-1f is a confirmed rocky exoplanet located in the habitable zone of the Trappist-1 system.
- It has well-constrained mass and radius:
  - M = 1.039±0.031 Earth masses
  - R = 1.045 Earth radii
- By understanding the interior composition of Trappist-1f, we can assess its habitability potential, compare its structure with Earth's, and evaluate the significance of stellar composition on planet formation.

Image Source: https://science.nasa.gov/asset/hubble/the-trappist-1-habitable-zone/

Methods

01 Stellar Composition Analysis

02 Contextual Comparison

03 Structure Modeling and Parameter Tuning

04 Mantle Mineralogy Comparison

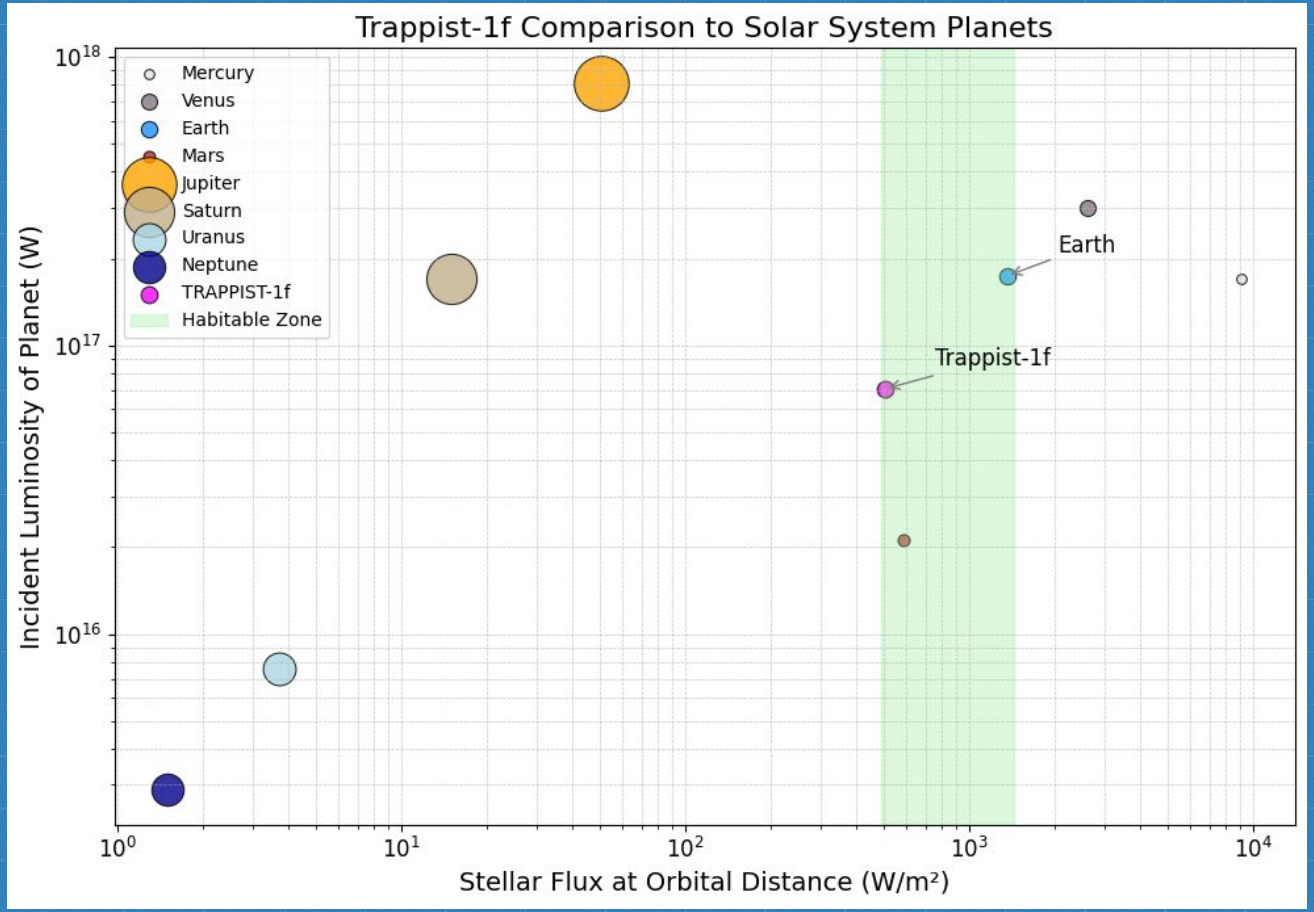
Important Equations

$$f_d = \frac{L_*}{4\pi d^2}$$

Stellar Flux at Orbital Distance of the Planets

$$I = f_d \times \pi r^2$$

Incident Luminosity of Planet


Trappist-1f Comparison to Solar System Planets
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
TRAPPIST-1f
Habitable Zone
Earth
Trappist-1f
Incident Luminosity of Planet (W)
Stellar Flux at Orbital Distance (W/m²)
10^{18}
10^{17}
10^{16}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

Results: Stellar Composition

Ratios	Values (dex)
Fe/H	0.05350
Mg/H	0.1635
Si/H	0.0785
Si/Mg	0.6167
Fe/Mg	0.7762

Results: Initial Structure Modeling

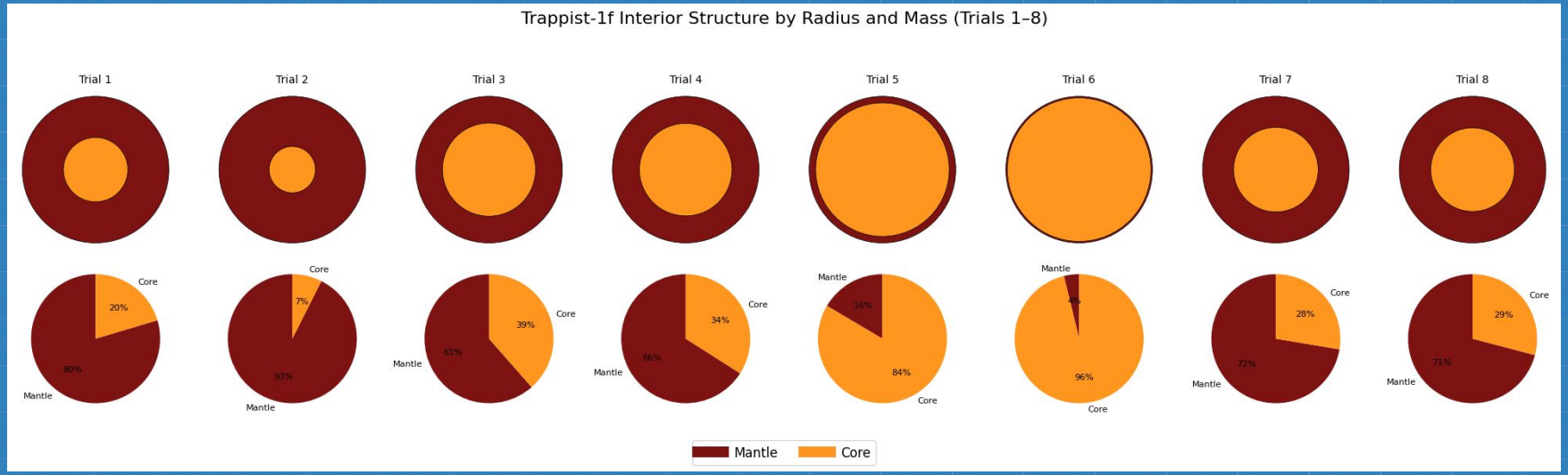
	Using Measured Mass Only	Including the Uncertainties
Mass	1.039 Earth masses	Upper Limit: 1.07 Earth masses Lower Limit: .008 Earth masses
Radius	1.011 Earth radii	Upper Limit: 1.020 Earth radii Lower Limit: 1.003 Earth radii
Core Mass Fraction	33.68	Upper Limit: 33.68 Lower Limit: 33.68
Core Radius Fraction	53.32	Upper Limit: 53.28 Lower Limit: 53.36
Density	5525.0 kg m^{-3}	Upper Limit: 5540.5 kg m^{-3} Lower Limit: 5489.4 kg m^{-3}

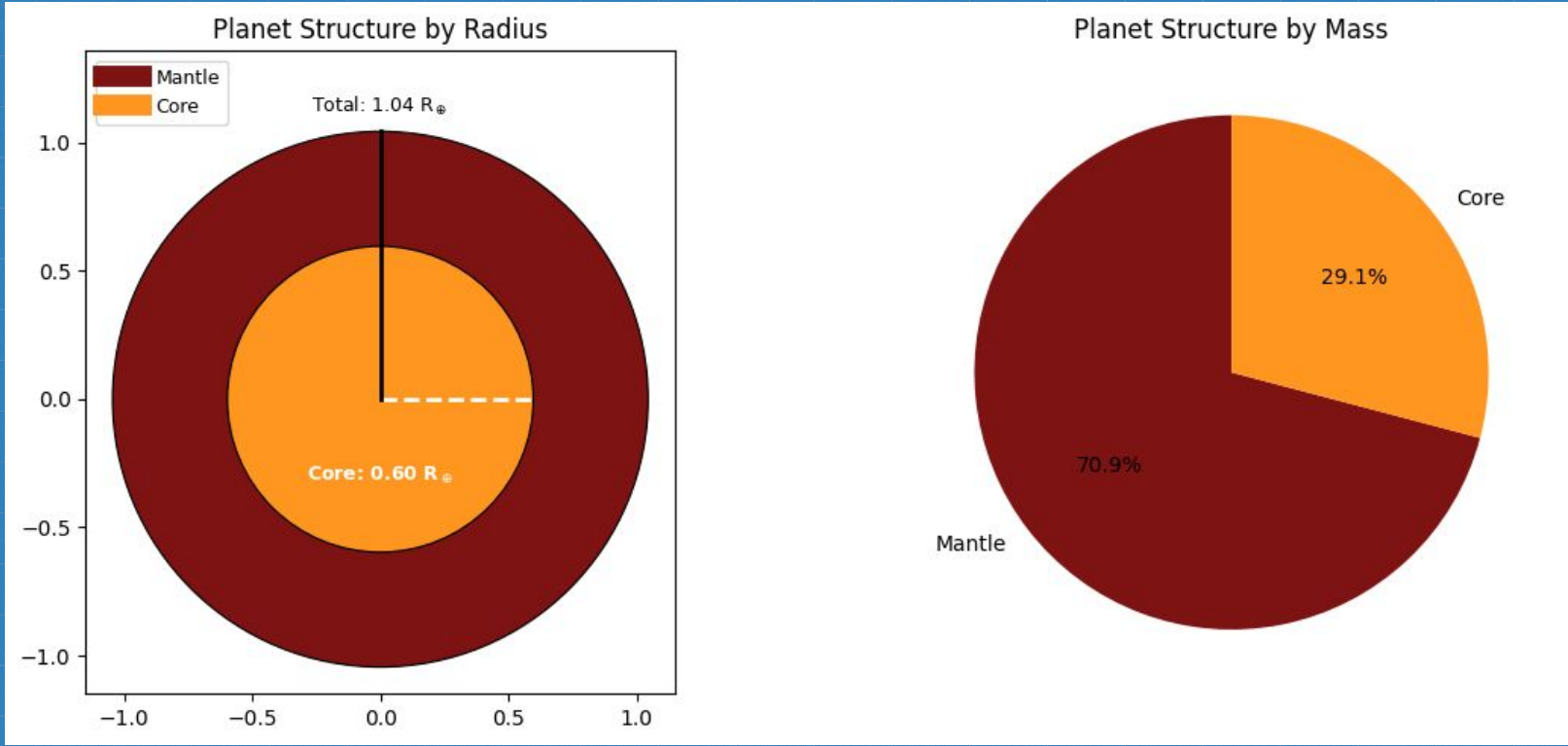
1.011 Earth radii

The Expected Radius

5525 kgm^{-3}

The Average Density


Trappist-1f Interior Structure by Radius and Mass (Trials 1–8)
Trial 1
Trial 2
Trial 3
Trial 4
Trial 5
Trial 6
Trial 7
Trial 8
Core
20%
80%
Mantle
Core
7%
93%
Mantle
Core
39%
61%
Mantle
Core
34%
66%
Mantle
Mantle
16%
84%
Core
Mantle
4%
96%
Core
Core
28%
72%
Mantle
Core
29%
71%
Mantle
Mantle
Core


Planet Structure by Radius
Mantle
Core
Total: 1.04 R⊕
Core: 0.60 R⊕
1.0
0.5
0.0
−0.5
−1.0
−1.0
−0.5
0.0
0.5
1.0
Planet Structure by Mass
Core
29.1%
70.9%
Mantle

Results: Mantle Mineralogy

Ratios	Trial 8	Earth
FeO	8.52%	8.18%
SiO^2	36.5%	44.71%
MgO	45.4%	38.73%
CaO	4.42%	3.17%
Al^2O^3	5.17%	3.98%

Conclusion

- We used stellar composition, mass, and radius to model the internal structure of Trappist-1f using the ExoPlex software.
- Our models suggest Trappist-1f has:
  - A core mass fraction of ~29–34%
  - A core radius fraction of ~57%
  - A bulk density of approximately 5525 kg/m^3, comparable to Earth
- The planet lies within the habitable zone and receives moderate stellar flux, supporting the possibility of surface habitability under appropriate atmospheric conditions.
- Mineralogy analysis shows a mantle composition similar to Earth's, with slightly elevated MgO and FeO fractions.
- Overall, our results highlight the importance of stellar refractory abundances in constraining planetary interior models and suggest that Trappist-1f is a differentiated rocky planet, which is similar in many ways to Earth.

THANKS!