TRAPPIST-1 To-Scale Simulation

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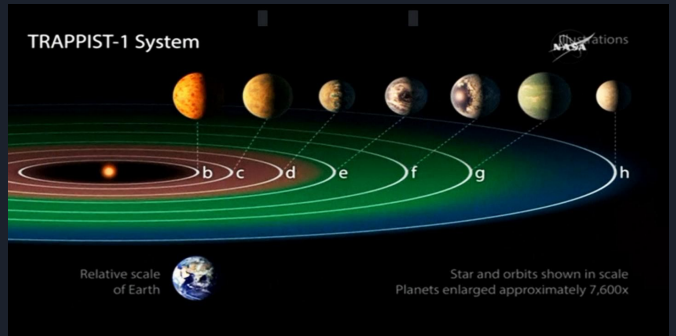
Background Info

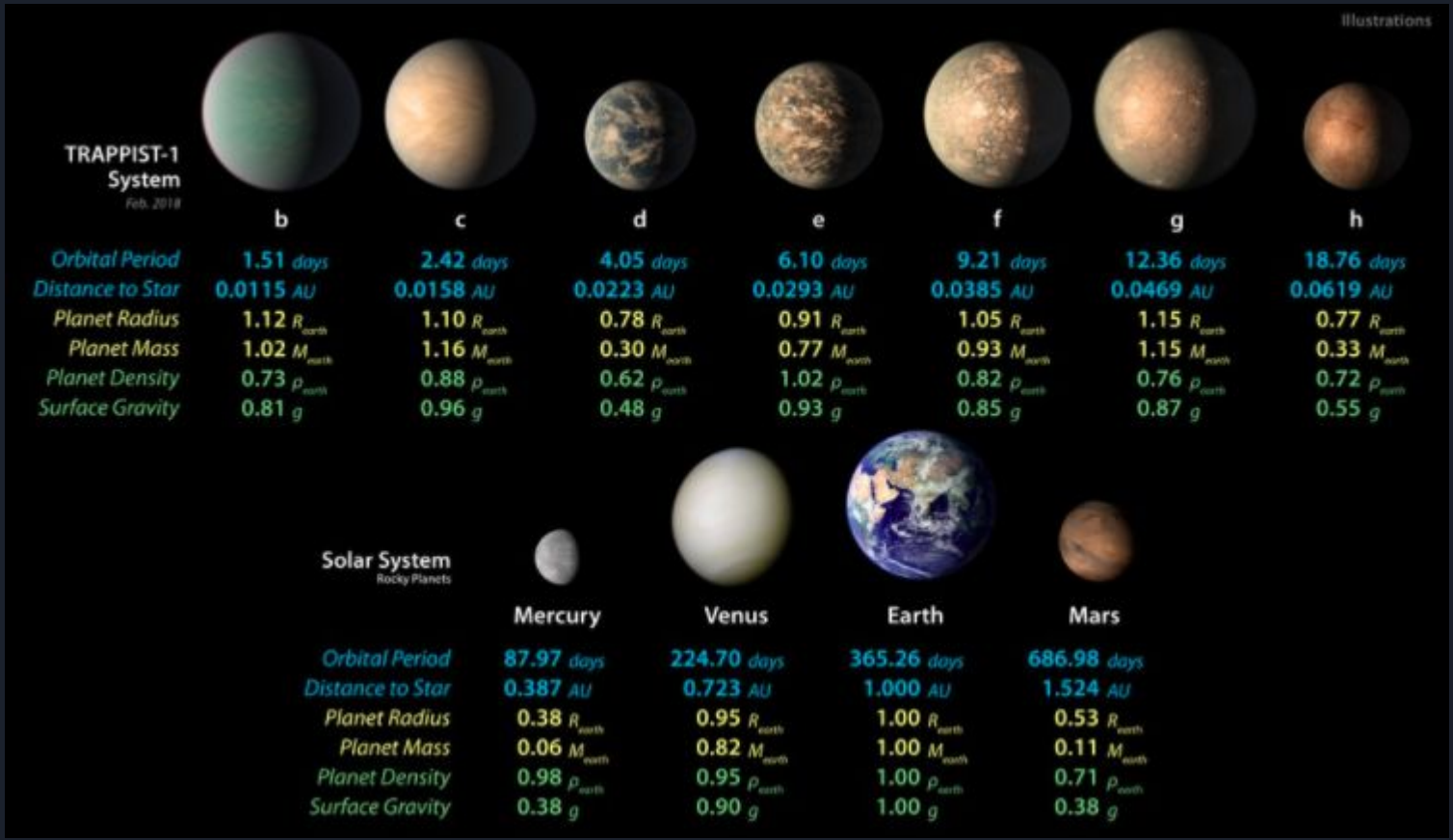
- The TRAPPIST-1 system is around 40 light years away and hosts 7 Earth-sized, potentially habitable worlds that orbit around a Jupiter-sized red dwarf
- TRAPPIST-1 is the most famous and studied exoplanetary system to date, as there are very few Earth-sized planets that we know of, let alone seven in the same exosolar system
- Spectroscopy has found evidence of water vapor on the two closest planets, liquid water on the middle three planets, and ice on the two furthest planets, making all of these worlds potentially support life as we know it



Methods and Techniques

- We used the data from SPITZER Space Telescope article on TRAPPIST-1 Planet Data
- Converted AU to Earth radii to make the orbits to scale
- Changed the velocity vectors to make orbits more circular.

```
scene_autoscale = False
scene = display(width = 1000, height = 1000, center = vector(0,0,0))
sphere(pos = vector(0,0,0), texture = "https://i.imgur.com/1nVWbbd.jpeg", radius = 5000, shininess = 0) #Display Size
Trappist1a = sphere(pos = vector(0,0,0),radius=13.21,color = color.red) # creates sphere
Trappist1b = sphere(pos = vector(-282.94,-10,0),radius = 1.12, color = color.orange, make_trail = True)
Trappist1b_V = vector(0,0,4) #Velocity
Trappist1c = sphere(pos = vector(-383.798,-10,0),radius = 1.1, color = color.yellow, make_trail = True)
Trappist1c_V = vector(0,0,3.5)
Trappist1d = sphere(pos = vector(-536.25,-10,0),radius = 0.78, color = color.green, make_trail = True)
Trappist1d_V = vector(0,0,3)
Trappist1e = sphere(pos = vector(-700.43,-10,0),radius = 0.91, color = color.blue, make_trail = True)
Trappist1e_V = vector(0,0,2.6)
Trappist1f = sphere(pos = vector(-916.22,-10,0),radius = 1.05, color = color.purple, make_trail = True)
Trappist1f_V = vector(0,0,2.3)
Trappist1g = sphere(pos = vector(-1113.23,-10,0),radius = 1.15, color = color.magenta, make_trail = True)
Trappist1g_V = vector(0,0,2.13)
Trappist1h = sphere(pos = vector(-1465.06,-10,0),radius = 0.77, color = color.red, make_trail = True)
Trappist1h_V = vector(0,0,1.86)
```


Illustrations
TRAPPIST-1 System
Feb. 2018
b
c
d
e
f
g
h
Orbital Period 1.51 days 2.42 days 4.05 days 6.10 days 9.21 days 12.36 days 18.76 days
Distance to Star 0.0115 AU 0.0158 AU 0.0223 AU 0.0293 AU 0.0385 AU 0.0469 AU 0.0619 AU
Planet Radius 1.12 R_{earth} 1.10 R_{earth} 0.78 R_{earth} 0.91 R_{earth} 1.05 R_{earth} 1.15 R_{earth} 0.77 R_{earth}
Planet Mass 1.02 M_{earth} 1.16 M_{earth} 0.30 M_{earth} 0.77 M_{earth} 0.93 M_{earth} 1.15 M_{earth} 0.33 M_{earth}
Planet Density 0.73 ρ_{earth} 0.88 ρ_{earth} 0.62 ρ_{earth} 1.02 ρ_{earth} 0.82 ρ_{earth} 0.76 ρ_{earth} 0.72 ρ_{earth}
Surface Gravity 0.81 g 0.96 g 0.48 g 0.93 g 0.85 g 0.87 g 0.55 g
Solar System
Rocky Planets
Mercury
Venus
Earth
Mars
Orbital Period 87.97 days 224.70 days 365.26 days 686.98 days
Distance to Star 0.387 AU 0.723 AU 1.000 AU 1.524 AU
Planet Radius 0.38 R_{earth} 0.95 R_{earth} 1.00 R_{earth} 0.53 R_{earth}
Planet Mass 0.06 M_{earth} 0.82 M_{earth} 1.00 M_{earth} 0.11 M_{earth}
Planet Density 0.98 ρ_{earth} 0.95 ρ_{earth} 1.00 ρ_{earth} 0.71 ρ_{earth}
Surface Gravity 0.38 g 0.90 g 1.00 g 0.38 g

Findings and Results

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Reflection

Through simulating the TRAPPIST-1 system, we figured out how to model and share our model through the process of animation in vpython. This will be integral in our future research to not only create, but also share. One of our main triumphs was being able to do a full to-scale model in terms of orbital period, distance to the star, planet radius, and gravitational effect. Figuring out how to scale each of these factors, especially when they affected each other, was a challenge; but we were able (after 66 notebooks!) to fit every puzzle piece into place. We set out to create a full to-scale model of the system, and came out with two! We were able to successfully take on an astrophysics-related coding project and prepare ourselves for similar challenges in the future.

References and Citations

[1] Raphael Baer-Way

[2] https://www.spitzer.caltech.edu/image/ssc2018-04c-trappist-1-planet-data-feb-2018

[3] http://www.trappist.one

[4] https://solarsystem.nasa.gov/news/335/10-things-all-about-trappist-1/

[5] https://www.space.com/42512-trappist-1-planet-could-host-life.html

[6] https://www.glowscript.org/docs/VPythonDocs/canvas.html

[7] http://cstl-csm.semo.edu/mlcobb/PH370/VPythonTutorial.pdf