Solar System Habitability Zone Model

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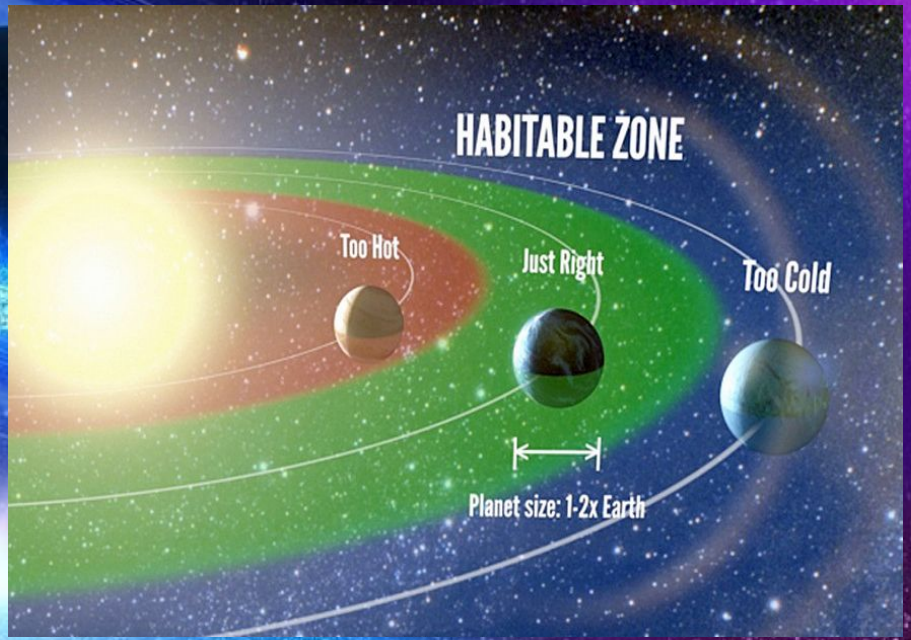
Research Question / Goals

Can we accurately model the habitability of a given solar system?

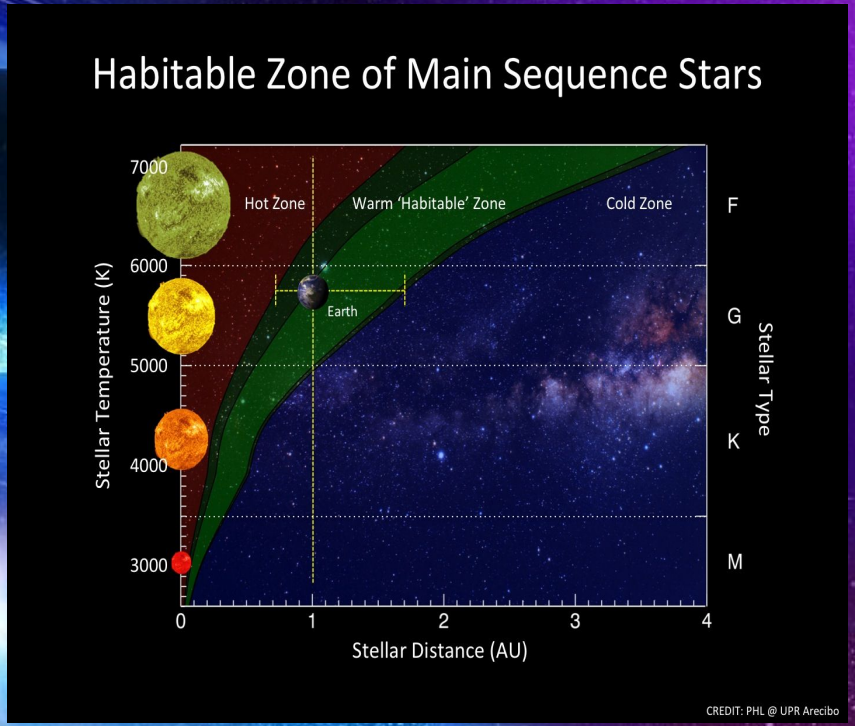
- Predict the habitability of planets inside a given solar system
- Create a model of the solar system with the habitability and planets shown

- The habitable zone can be classified as the distance from a star at which liquid water could exist on orbiting planets' surfaces.



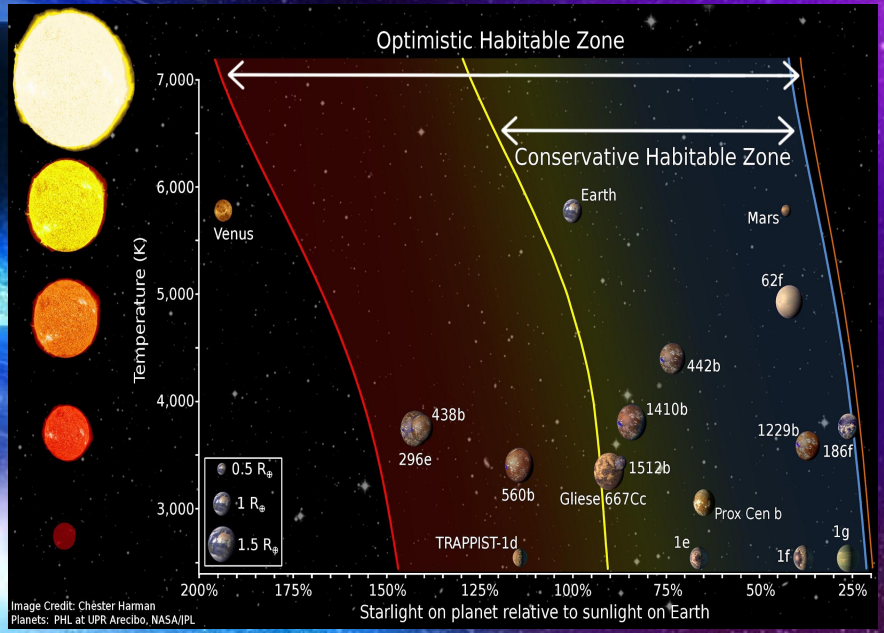
Plans Going Into The Project

- Use data collected from the Kepler Space Telescope
- Create classes for the planets, stars, and solar systems
- Utilize the classes in combination with one another to visualize a solar system and print the habitability of each planet



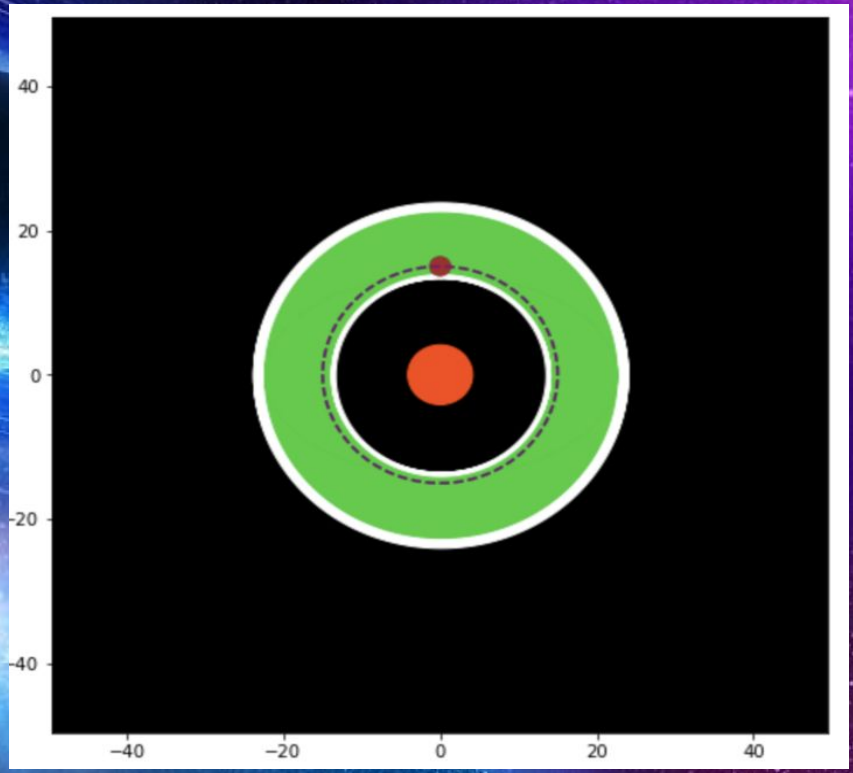
Methodology

- Utilized object oriented programming to create classes for the planets, stars, and solar system
- Calculated the effective temperature at a distance from surface temperature and luminosity
- Used numpy and matplotlib to plot the system and habitable zones
- Determines where the planets were in the system using boolean operators



Methodology (Visualization)

- Each visualization contains three key variables:
  - The orbit of the planets
  - The habitability zones
  - The star's color based on spectral type
- The plots will also have 10° buffer zones around the habitability zone
- Early example of visualization shown.



Testing/Final Results

- Can print out the habitability status of each planet in the system
- Not limited by number of planets
- Can plot visualizations of the solar system at an appropriate scale

Key for the visualizations on the following slide:

- Green area is habitable
- White area is possibly habitable
- Dotted lines are planet orbits

```
GJ 3293 b is within the habitable zone
GJ 3293 c is too far from the star to be habitable
GJ 3293 d is within the habitable zone
GJ 3293 e is too close to the star to be habitable
```

```
HD 23472 b is too close to the star to be habitable
HD 23472 c is too close to the star to be habitable
HD 23472 d is too close to the star to be habitable
HD 23472 e is too close to the star to be habitable
HD 23472 f is too close to the star to be habitable
```

```
TRAPPIST-1 b is too close to the star to be habitable
TRAPPIST-1 c is too close to the star to be habitable
TRAPPIST-1 d is within the habitable zone
TRAPPIST-1 e is within the habitable zone
TRAPPIST-1 f is within the habitable zone
TRAPPIST-1 g is too far from the star to be habitable
TRAPPIST-1 h is too far from the star to be habitable
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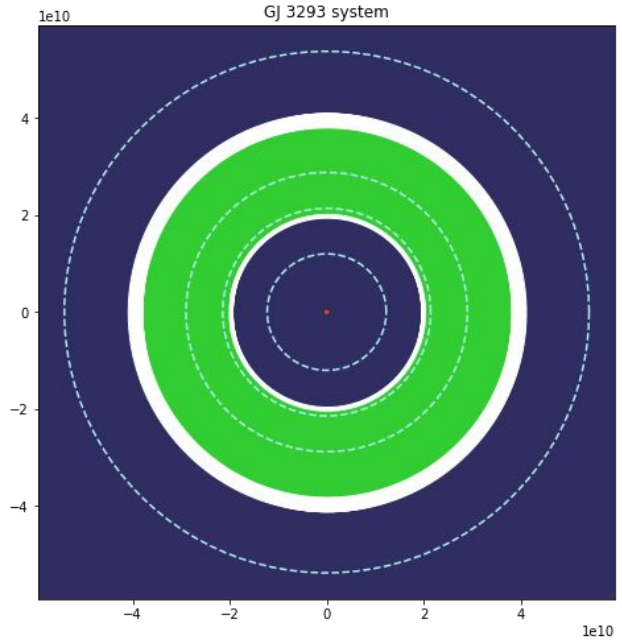
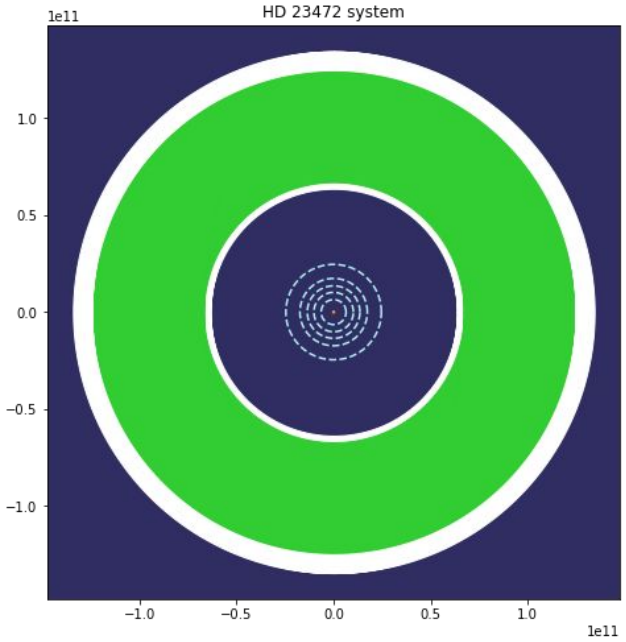
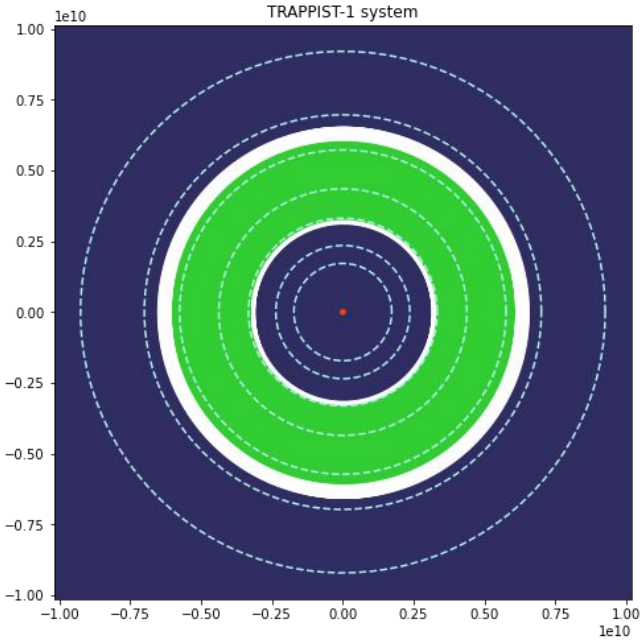
Final Visualizations

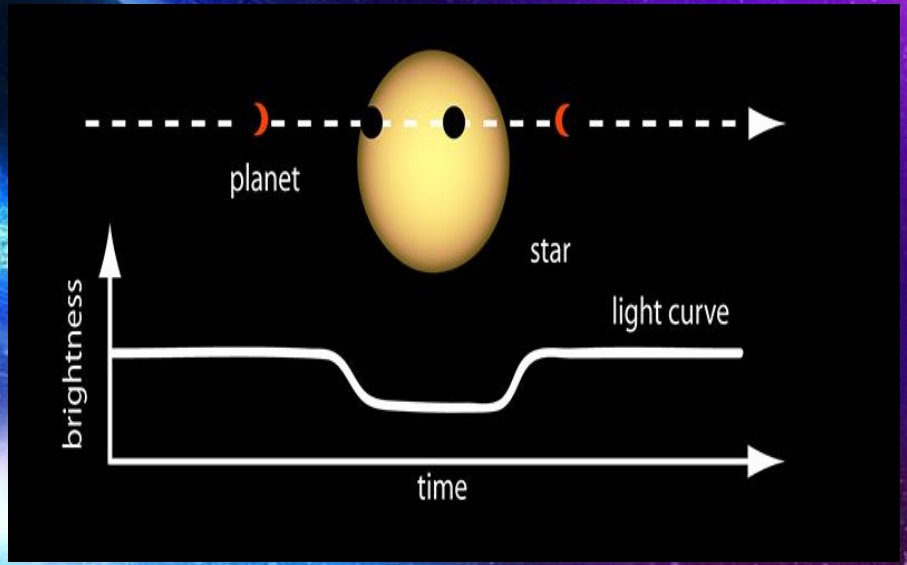






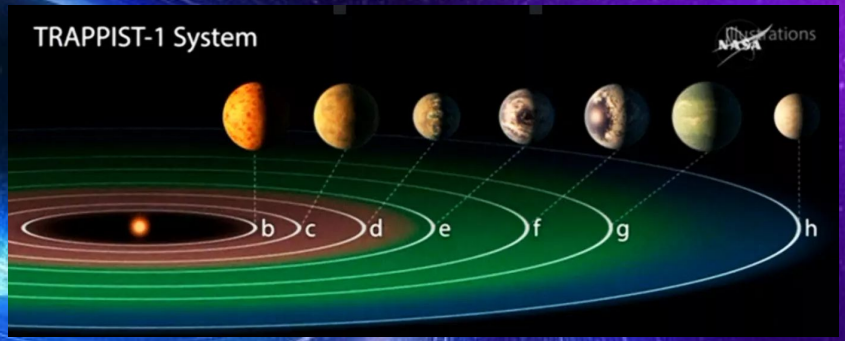
Limitations and Complications

- Cannot model massive stars
- We don’t have info about the planet makeup or atmosphere
- Habitability zones solely based on star temperature
- Kepler data being used only finds planets transiting stars (image for example)
- Approximating eccentric orbits as circular
- Some systems don’t have all the data we need
- Distance unit conversions caused roadblock



Conclusion

- Successfully able to predict and model the habitability of planets inside a given solar system.
- Approximately matched the published results of Trappist-1 (shown on right)



Limiting factors can be worked around and accounted for to lead to even more accurate predictions of the habitable zones.

Sources

“Nasa Exoplanet Archive.” *Planetary Systems*, https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbls&config=PS. Here

University of Maryland. “Lecture 14.” *The Habitable Zone*. Here