Exoplanet Habitable Zones Instructions

In this project we are going to think about the habitability of exoplanets! We're going to be working with the Exoplanets Archive, a database that tracks every exoplanet detected so far. In the first part of the project, you'll practice working with the database and take a look at different planet properties. Then we'll make a calculator to find habitable zones for each exoplanet system.

Background Reading
Exoplanets Article: https://exoplanets.nasa.gov/what-is-an-exoplanet/overview/
NASA Habitable Zone Article: https://exoplanets.nasa.gov/search-for-life/habitable-zone/
Questions to think about:
- What is an exoplanet and why do we study them?
- What is the habitable zone and why are we interested in it?
- What kinds of factors might determine whether a planet is habitable?
- In the simplest case of defining the habitable zone as where liquid water can exist, what temperatures set the inner and outer extent of the habitable zone?

Explore the data — See Jupyter Notebook

Make a habitable zone calculator
Background: When an object emits light, we can write the amount of energy it outputs as $L = 4\pi R^2 \sigma T^4$, where R is the radius of the object, T is the temperature, and σ is a constant ($\sigma = 5.67 \times 10^{-5}$ erg/cm^2/s/K^4). The units of the constant σ determine what units R, T, and L have (cm, K, and erg/s, respectively).

Let's come up with an equation to describe the distances from the star that comprise the habitable zone.

1. Think about our definition of the habitable zone. What temperature does a planet surface need to be to be considered part of the habitable zone?
2. Let's start with the simplest model for a planet's temperature. In reality planets (like Earth) can have internal heating and/or thick atmospheres that help the planet retain extra heat, but for now we're going to pretend that all of a planet's heat comes from the host star.
    1. Draw a diagram of a host star (with some radius R_star and temperature T_star) and a planet (with some radius R_planet and temperature T_planet), with a distance of d between them.
    2. The light from the star will radiate outwards in all directions. If a star puts out L amount of energy every second, can you come up with an equation that describes what fraction of that energy will be collected by the planet? Call the energy the planet collects L_collect. (Hint: think about the area of the planet that can collect light)
    3. The planet collects the energy from the star and then re-radiates it. Let's first assume the planet re-radiates all the energy it collected from the star. Write an expression for the temperature of the planet based on L_collect.

4. Substitute your L_collect expression into step 3. What does the temperature of your planet depend on?
5. It will also be helpful to have an equation for the distance between the star and planet versus the temperatures of the star and planet. To this end, rearrange your equation in part 4 to solve for the distance.

Make note of all the variables for each of your equations in parts 4 and 5 (you'll need these for your code later).

Based on the equation you wrote, and your new knowledge of python, write out two functions. One should return the temperature of the planet, and the other should return a distance to the planet. The inputs should be the variables you wrote down in the previous part.

Test your code and look for habitable zone planets! — See Jupyter Notebook