ASTRONOMY UNIT 8

Lab Two – TRAPPIST-1

Questions

Biological functions on Earth require the availability of liquid water. If we are to find life on other planets, it is reasonable that they also have liquid water. Every star has an orbital region where liquid water is possible on the surface. This is called the Circumstellar Habitable Zone, or simply habitable zone.

In our solar system, Venus and Mars are outside of this zone. Earth appears to be the only planet in our solar system capable of sustaining liquid water on its surface. In 2017, TRAPPIST-1 was discovered with multiple exosolar planets. Is it possible that planets outside our solar system can support liquid water at the surface?

Hypotheses

1. No planets in TRAPPIST-1 are in the habitable zone.
2. At least one planet in the TRAPPIST-1 system is in the star's habitable zone

Method

1. Calculate the **inner** bound for the habitable zone for TRAPPIST-1

$$r = \sqrt{\frac{(1-A)L_*}{16\pi\sigma T^4}}$$

r is radius of the inner boundary of the habitable zone in AU

A is the planetary bond Albedo (0.3)

*L** c the luminosity of TRAPPIST-1 (2.0097x10^23 watts)

σ is the Stefan Boltzmann constant (5.670374419...$\times 10^{-8}$ W·m^{-2}·K^{-4}) in watts, meters and kelvin

T is the target temperature (295 Kelvin for **inner** bound)

r_i =

2. Calculate the **outer** bound for the habitable zone for TRAPPIST-1

$$r = \sqrt{\frac{(1-A)L_*}{16\pi\sigma T^4}}$$

r is radius of the inner boundary of the habitable zone in AU

A is the planetary bond Albedo (0.3)

*L** is the luminosity of TRAPPIST-1 (2.0097x10^23 watts)

σ is the Stefan Boltzmann constant ($5.670374419... \times 10^{-8}\ W \cdot m^{-2} \cdot K^{-4}$) in watts, meters and kelvin

T is the target temperature (192 K for **outer** bound)

r_o =

3. For each planet in the TRAPPIST-1 system, calculate the planet's distance from TRAPPIST-1 in AU. Use the following equation from Kepler's Third Law

$$a_p^3 = \mu_{cb} \left({}^{T_p}/_{2\pi} \right)^2$$

a^3_p is the distance from TRAPPIST-1 in AU

μ_{cb} is star's gravitational parameter (1.06198x10^19 m^3/s^2)

T_p is the planet's orbital period in days (see table below)

Note: You will need to get the cube root of a^3_p and convert distance results in meters to AU
1 meter = 6.68459e-12 AU

Planet	Orbital Period (days)
TRAPPIST-1b	1.51087081
TRAPPIST-1c	2.4218233
TRAPPIST-1d	4.049610
TRAPPIST-1e	6.099615
TRAPPIST-1f	9.206690
TRAPPIST-1g	12.35294
TRAPPIST-1h	20

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1b

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1c

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1d

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1e

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1f

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1g

Calculate distance from TRAPPIST-1 star for planet TRAPPIST-1h

4. Compare the distances to the inner and outer bounds of the habitable zone

Planet	distance (AU)	Inner Bound (AU)	Outer bound (AU)	Habitable Zone?
TRAPPIST-1b				
TRAPPIST-1c				
TRAPPIST-1d				
TRAPPIST-1e				
TRAPPIST-1f				
TRAPPIST-1g				
TRAPPIST-1h				

Conclusion