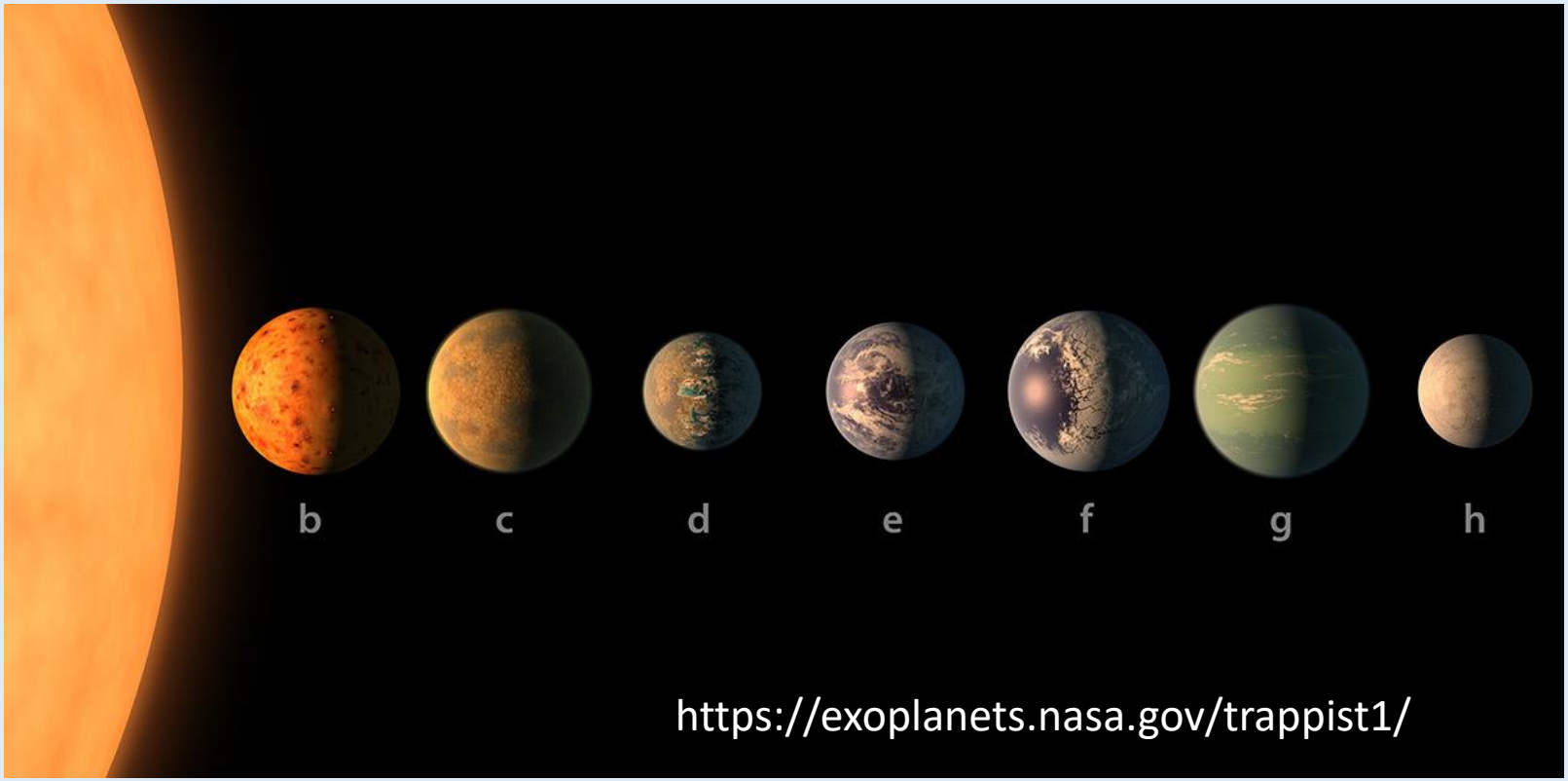
Theory: T-7

“Life on Other Planets ”

Motivation

- The search for exoplanets



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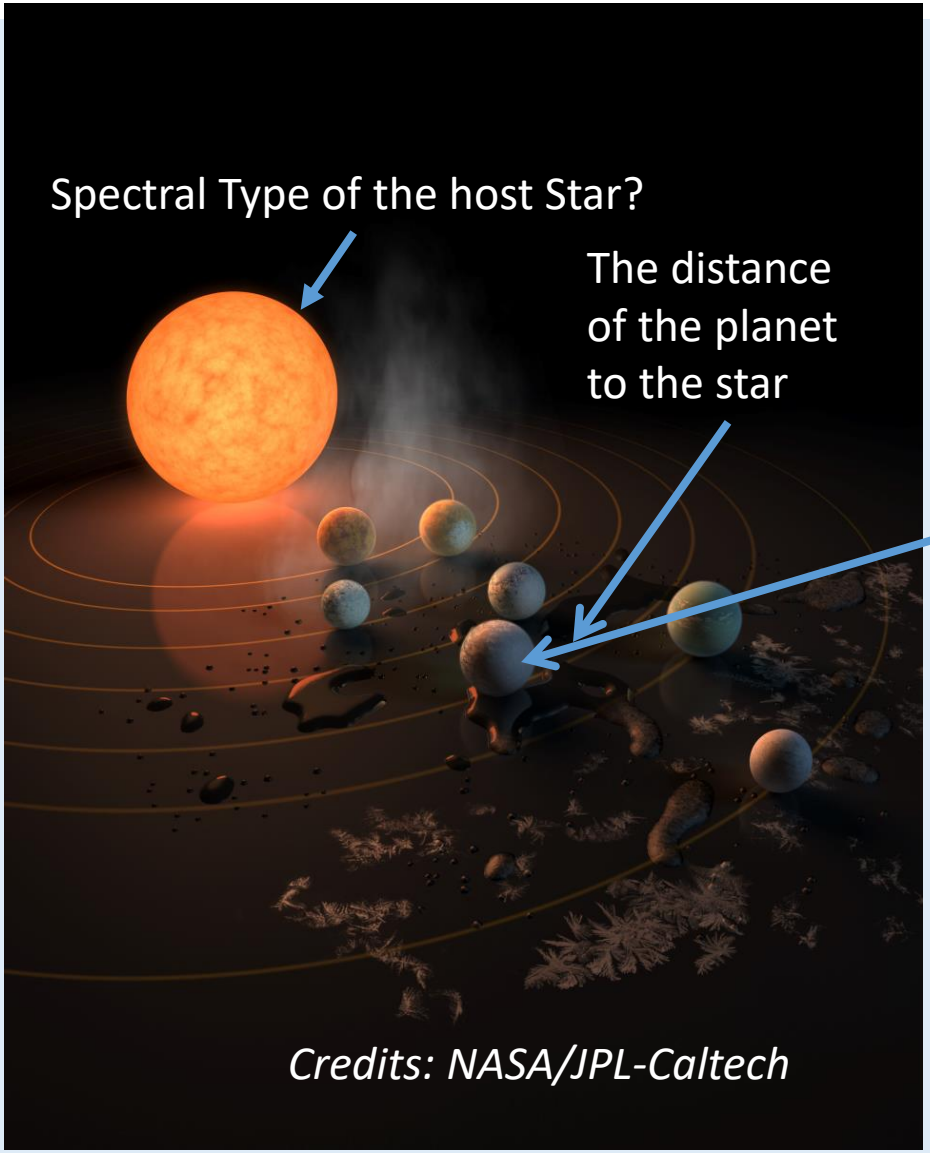
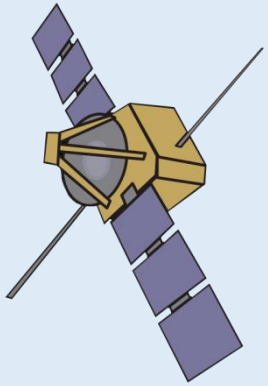


What is the smallest mass of the planet that can be detected ?



T-7 Life on Other Planets

Objectives

- Find the spectral type of the most massive star that astronomers should look for intelligent life
- Find the distance of the planets to a main sequence star
- Find the smallest mass of a planet that can be detected by Doppler shift effect

Task T7a (7 marks)

- If it takes at least 4 billion years to an intelligent life form to evolve, what is the spectral type of the most massive star that astronomers should look for intelligent life?.

$$L \propto M^{3.5} \qquad E \propto M \qquad \Rightarrow \qquad \tau = \tau_{\odot} \left(\frac{M_{\odot}}{M} \right)^{2.5}$$

Task T7b (5 marks)

- What is the expression for distance *d* in AU of the planet to its parent main sequence star of mass *M*.

$$P_{input} = (1-a)\frac{\pi r^2 L}{4\pi d^2} = (1-a)\frac{r^2 L}{4d^2} \quad \Leftrightarrow \quad P_{output} = 4\pi r^2 \alpha \sigma T^4$$

$$(1-a)\frac{r^2 L}{4d^2} = 4\pi r^2 \alpha \sigma T^4 \quad \Rightarrow \quad \frac{L}{d^2} = \frac{L_\odot}{d_\odot{}^2}$$

$$d = \left(\frac{M}{M_\odot}\right)^{3.5/2} \text{AU}$$

Task T7c (8 marks)

- Calculate the mass of a habitable planet, in units of Earth masses, that can be detected by Doppler shift effect.

$$T^2 = \frac{4\pi^2 d^3}{G(M+m)} \Rightarrow \omega = \sqrt{\frac{G(M+m)}{d^3}}$$

$$Md_s = md \Rightarrow v = \omega d \frac{m}{M} = \frac{m}{M}\sqrt{\frac{G(M+m)}{d}}$$

$$m = \frac{\Delta\lambda}{\lambda} c \sqrt{\frac{Md}{G}} \Rightarrow m = 3.31 \times 10^{24}\text{kg} = 0.593 M_{\oplus}$$

T-7 Life on Other Planets

Knowledge

- Basics Astrophysics
  - Thermodynamics
- Stars
  - Stellar Properties
  - Stellar Evolution
- Instrumentation & Space Technology
  - Instrumentation