TPS

- How many Exoplanets have been discovered to date?

A. 1-10
B. 11-100
C. 101-500
D. 501-1000

ExoPlanets

- Objectives
  - What are Exoplanets
  - How do we find Exoplanets
  - How do Exoplanets compare to our solar system?
  - What about habitable planets?

Is This What you Think of???

George Lucas looks like a terrible swordsman!
Put some effort into it!

Exoplanet Statistics

- Exoplanets: planets orbiting stars other than our Sun
- As of yesterday 896 planets around other stars have been confirmed

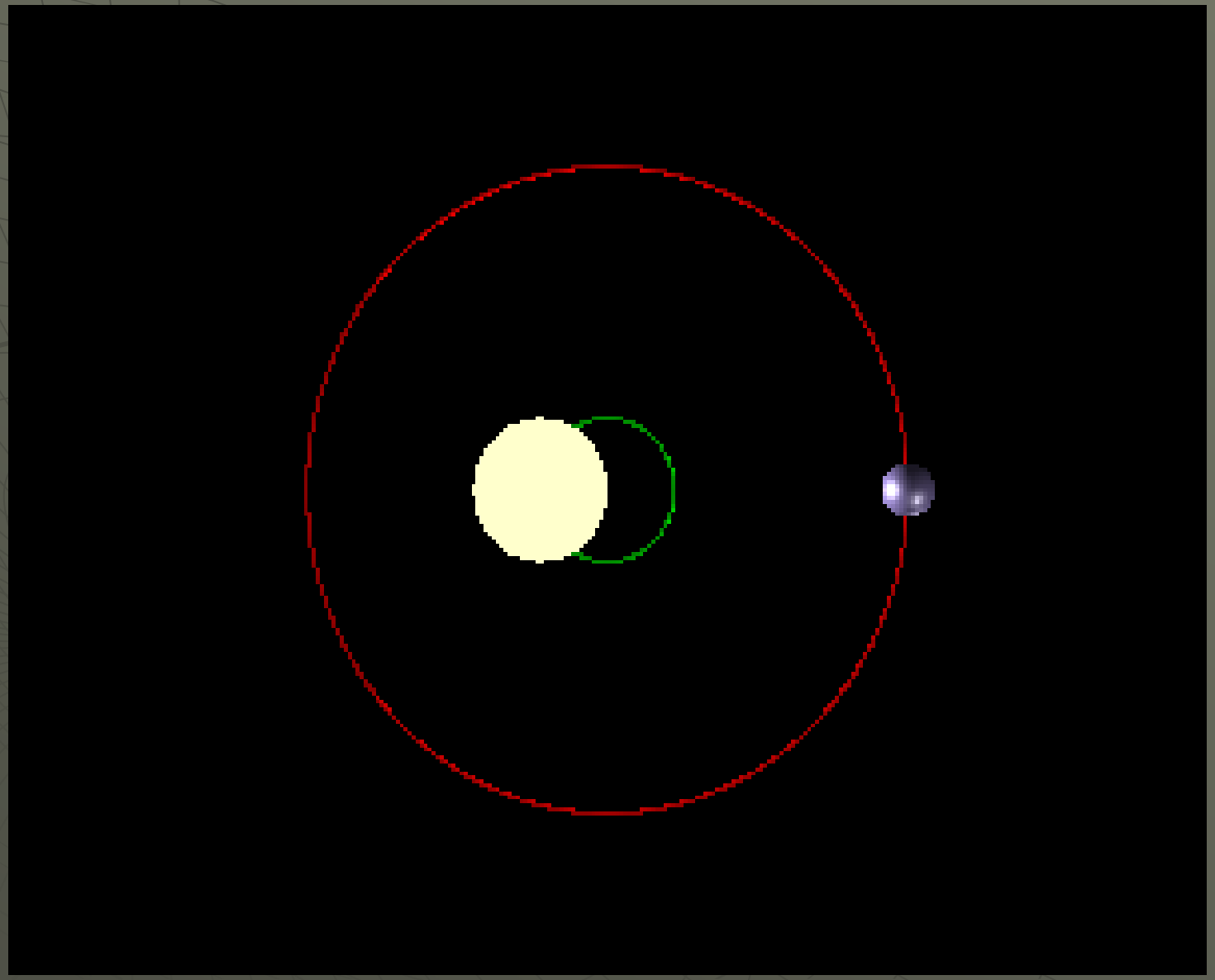
- Most are gas giants
- Most are close to their star (within Mars orbit)

- Why so few rocky planets???
  - Any guesses
  - A: method of discovery

How do we Find Exoplanets?

- Planets orbit their star
- Planet pulls on the parent star (think Earth-Moon tides)

Planets Pull on their Parent Star



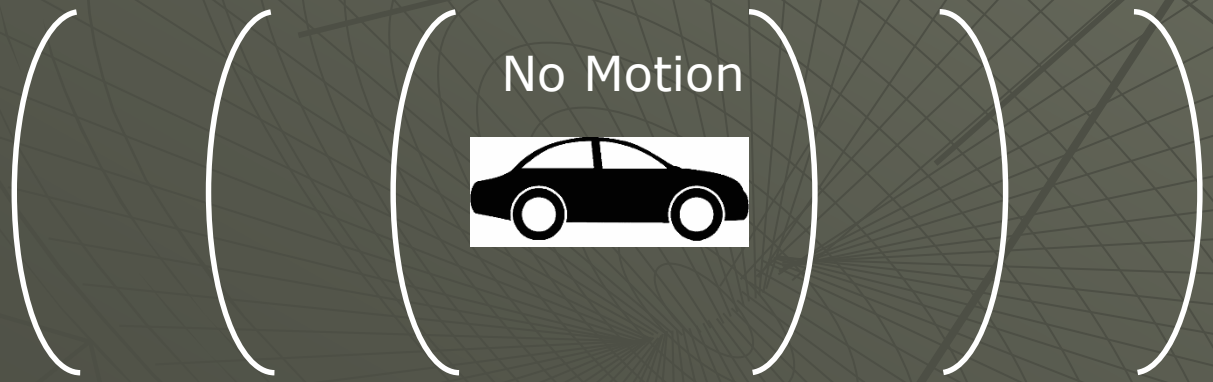
How do we Find Exoplanets?

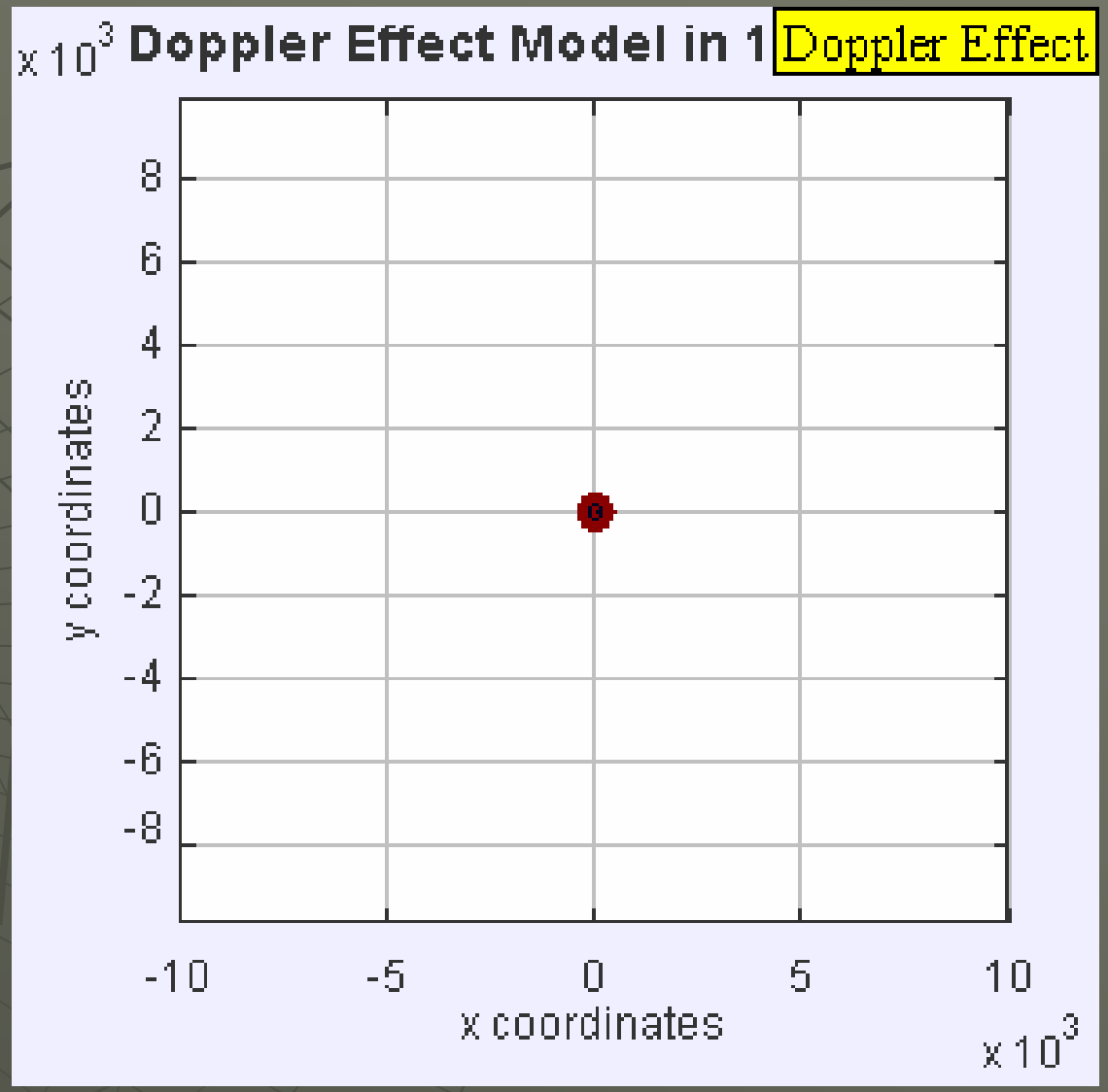
- how does light behave when emitted from a moving source?
- How do sound waves behave???

- What does a high speed car sound like before it passes you and after it passes you?

Object Emitting at Rest

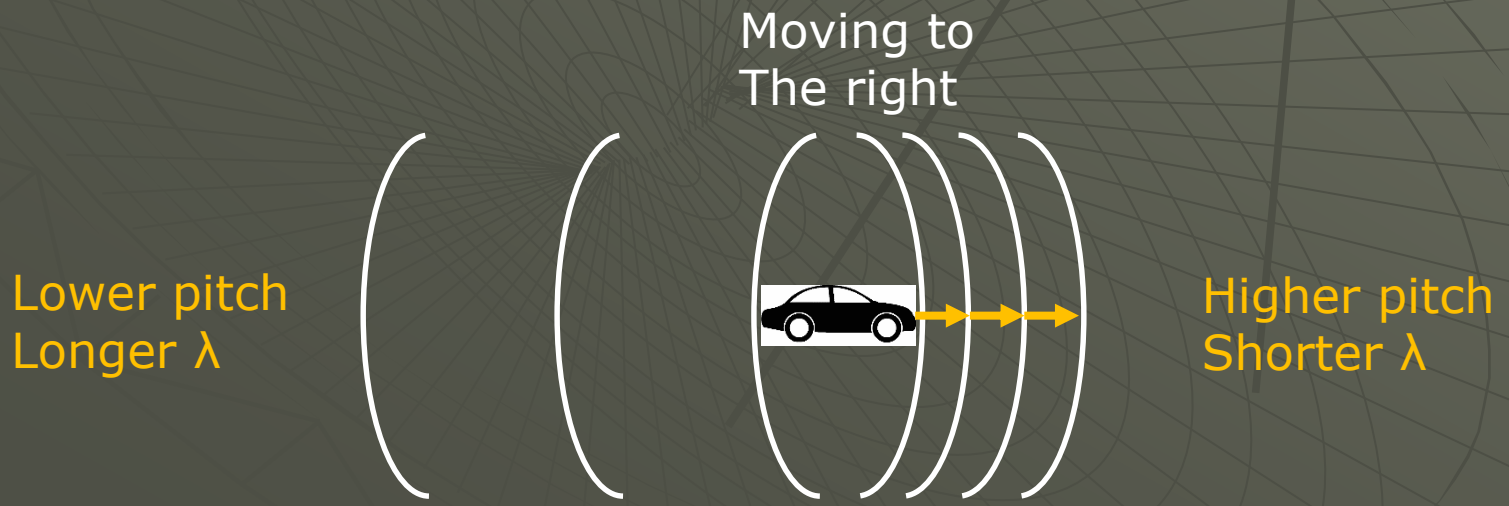
- Car emits a sound wave every second

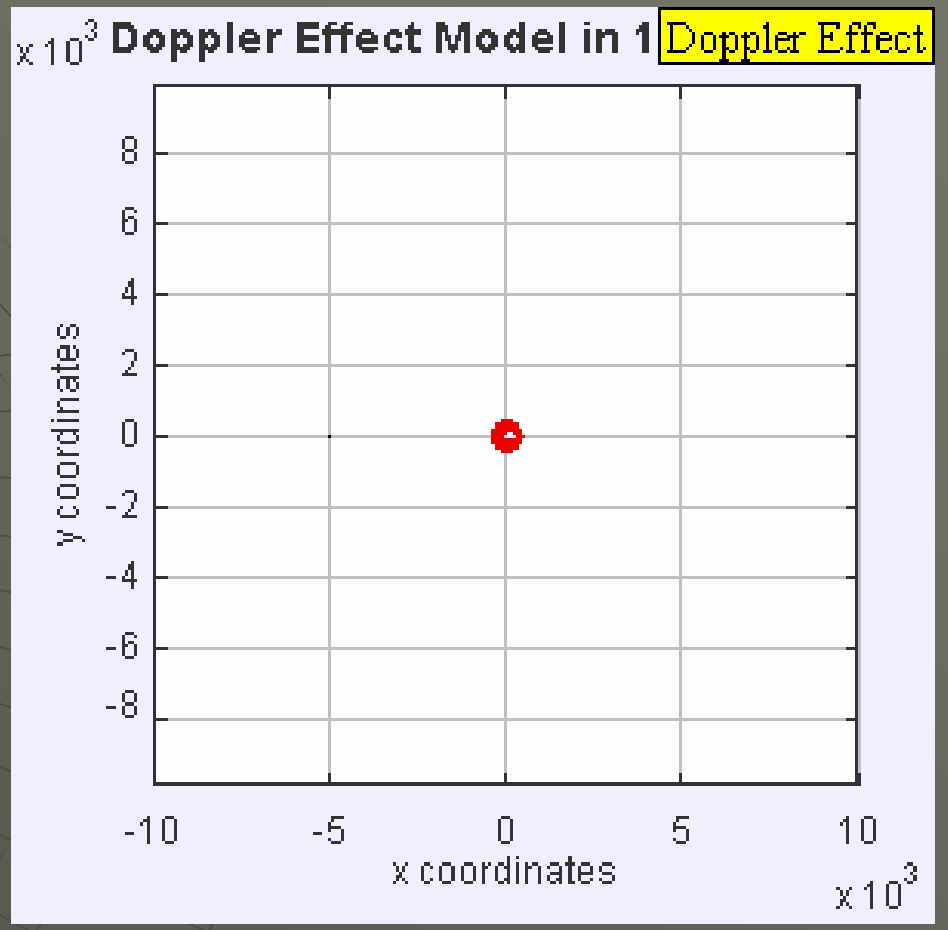




Pitch of Sound is the Frequency of Sound

- Higher pitch lower frequency → shorter wavelength
  - Still emitting a sound wave every second
  - In front: Is closer to the wave it sent a second ago
  - Higher pitched waves are closer together





Demo

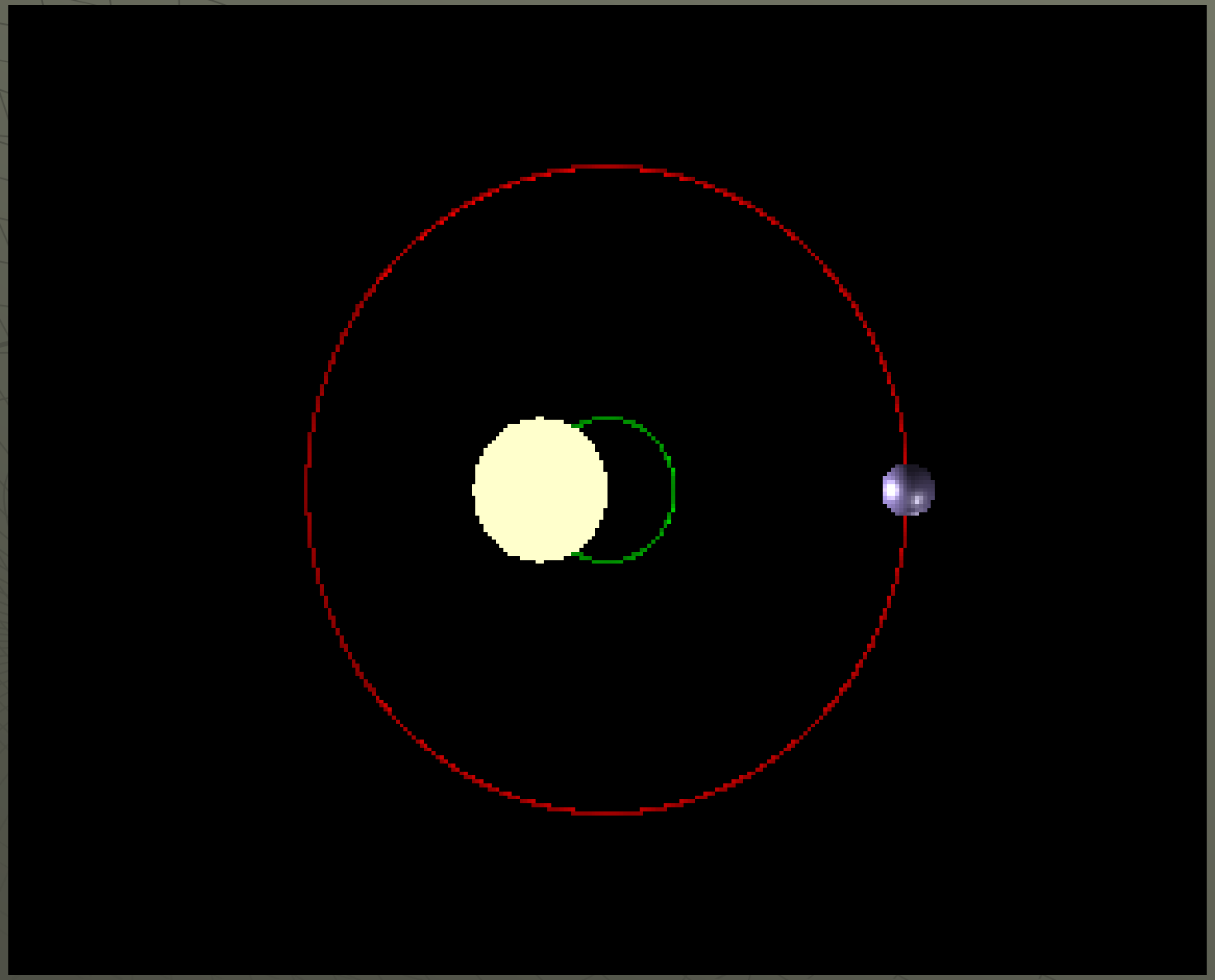
- What about a sound moving in a circle???

What Does This Have to do With Anything?

- Light is a wave and exhibits the same phenomenon as sound from a moving source
- Planets are moving sources causing their star to move
- Stars produce light

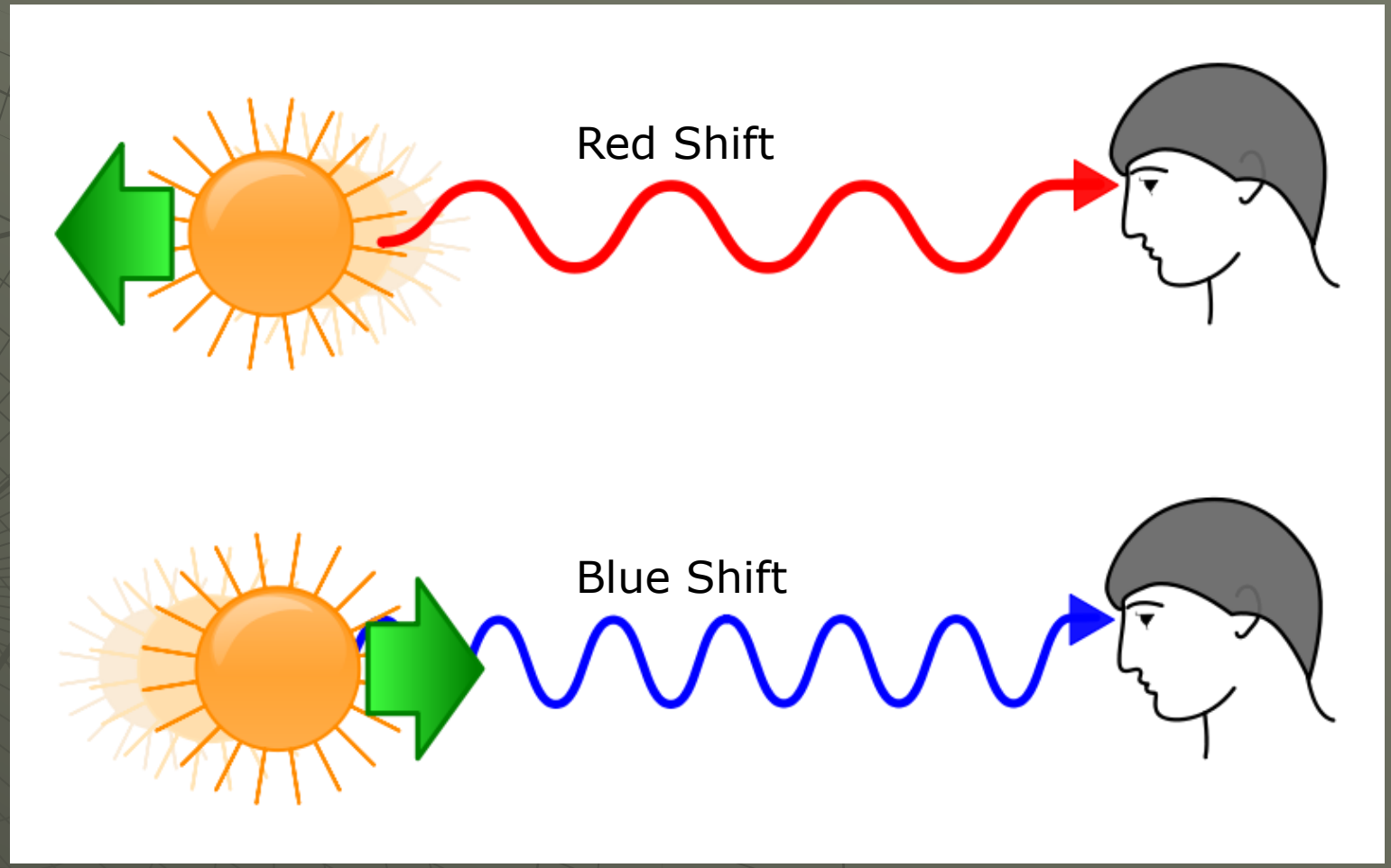
- A star is a moving, light emitting source!

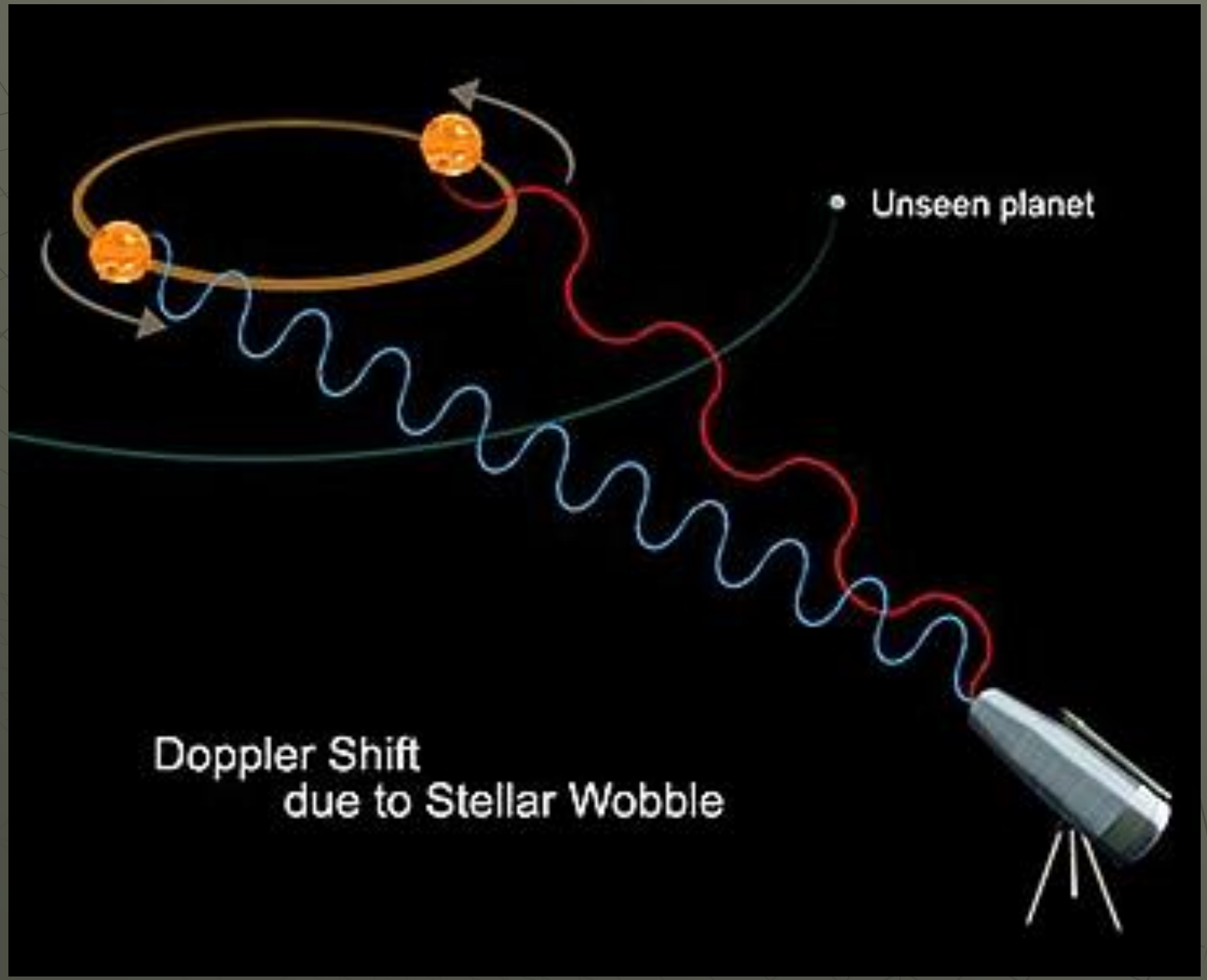
Planets Pull on their Parent Star



Doppler Shift of Light

- Electrons are moving with the source
- Moving away:
  - Electrons emit light with a longer wavelength
  - Emission/absorption lines shifted red
- Moving toward:
  - Electrons emit light with a shorter wavelength
  - Emission/absorption lines shifted blue




Unseen planet
Doppler Shift
due to Stellar Wobble

What We Actually Observe

- Doppler shift equation:

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

- $\Delta\lambda$ = wavelength change
  $= \lambda_0 - \lambda$
- λ_0 = emitted wavelength
- v = velocity of source
- c = speed of light

- $\Delta\lambda \sim v$
- The faster something is moving away/toward you → the greater the shift

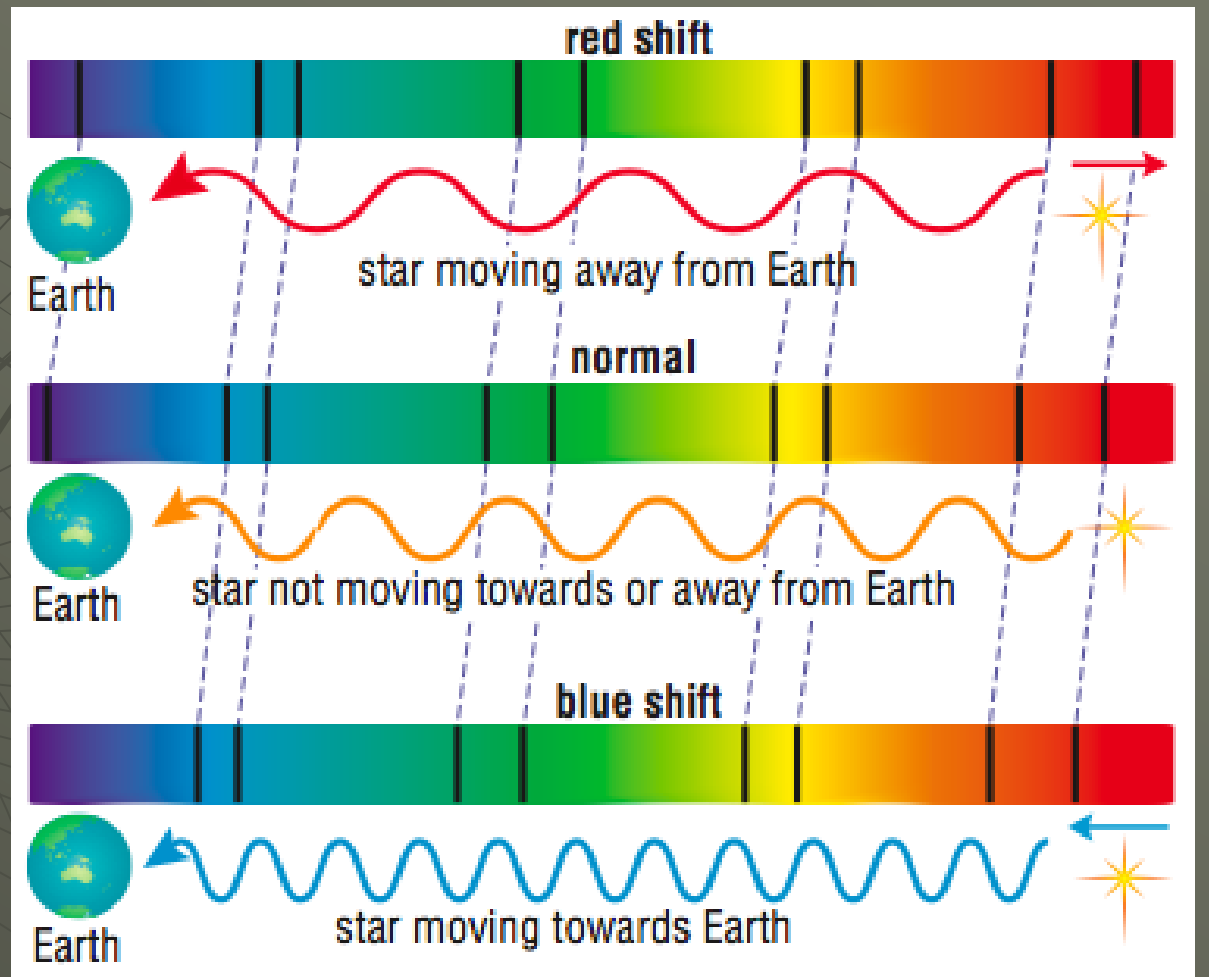


Fig 8.1.5 A red shift indicates that a star is moving away from us. A blue shift indicates that it is moving towards us.

TPS

- An observer measures the light emitted by an object and detects a redshift. Which of the following is correct?

A. The object is moving away from the stationary observer.
B. The observer is moving away from the stationary object.
C. The observer and object are both moving away from each other.
D. Any of the above may be true.

- The fact that the star Rigel is blue tells us that it is

A. moving toward us.
B. moving away from us.
C. a hot star.
D. a cold star.

- Which situation would you see a Doppler shift

A. A star moving away from us
B. A star moving perpendicular to our line of sight
C. A star not moving relative to us
D. All of the above

LT

- Doppler Shift
  - Pg. 75
  - Finally got my book!!!

Why Do We Mostly Observe Massive Planets

- A: Gravity

$$F = \frac{GMm}{r^2} = ma\ (movement)$$

- The bigger the planet, the bigger the movement of the parent star

How Do We Get Masses

- Spectroscopy:
  - Period from lines returning to starting shift
- Kepler's generic 3rd law:

$$M + m = \frac{r^3}{P^2}$$

- Mass comes from Newton's laws

$$F = \frac{GMm}{r^2} = ma\ (movement)$$

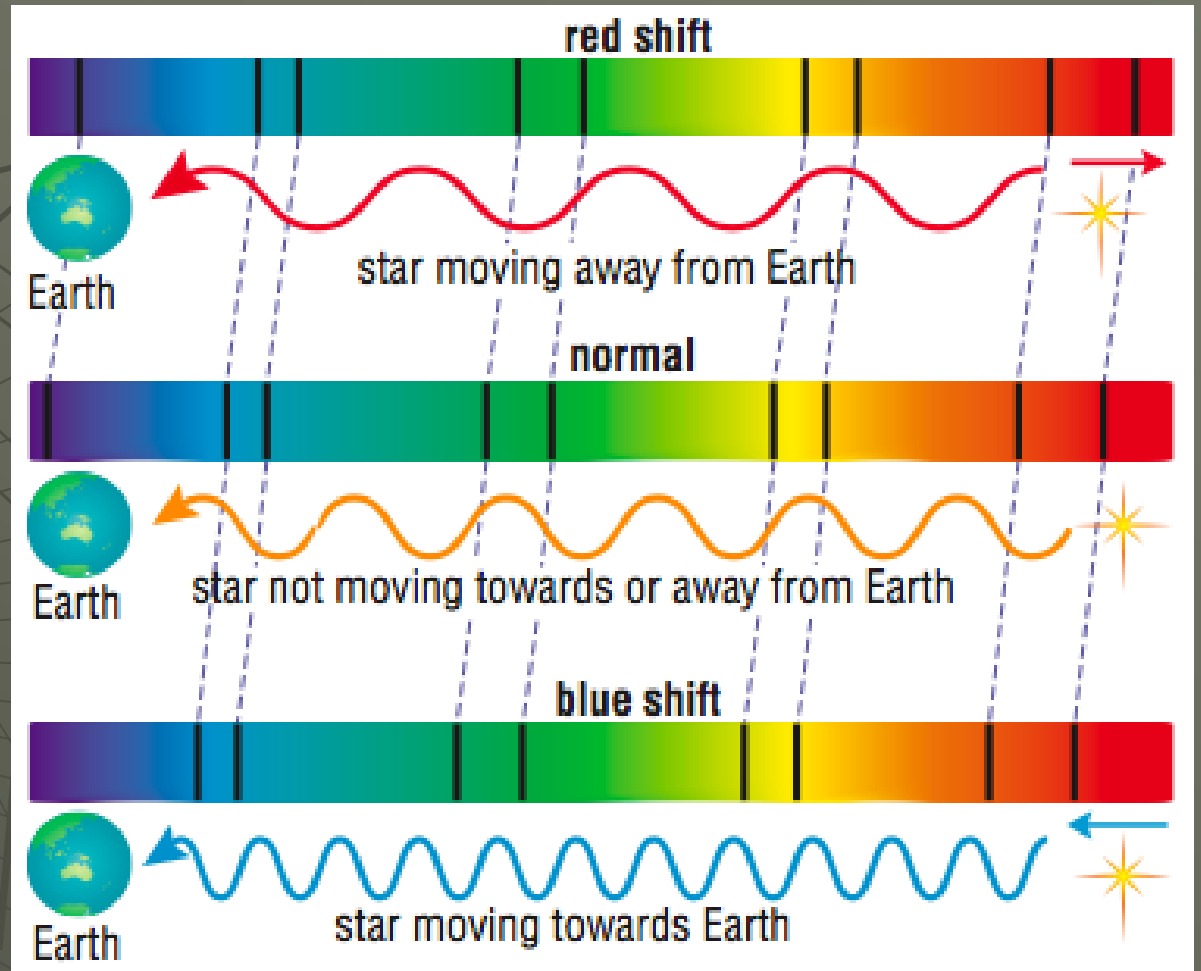


Fig 8.1.5 A red shift indicates that a star is moving away from us. A blue shift indicates that it is moving towards us.

What About Habitable Planets?

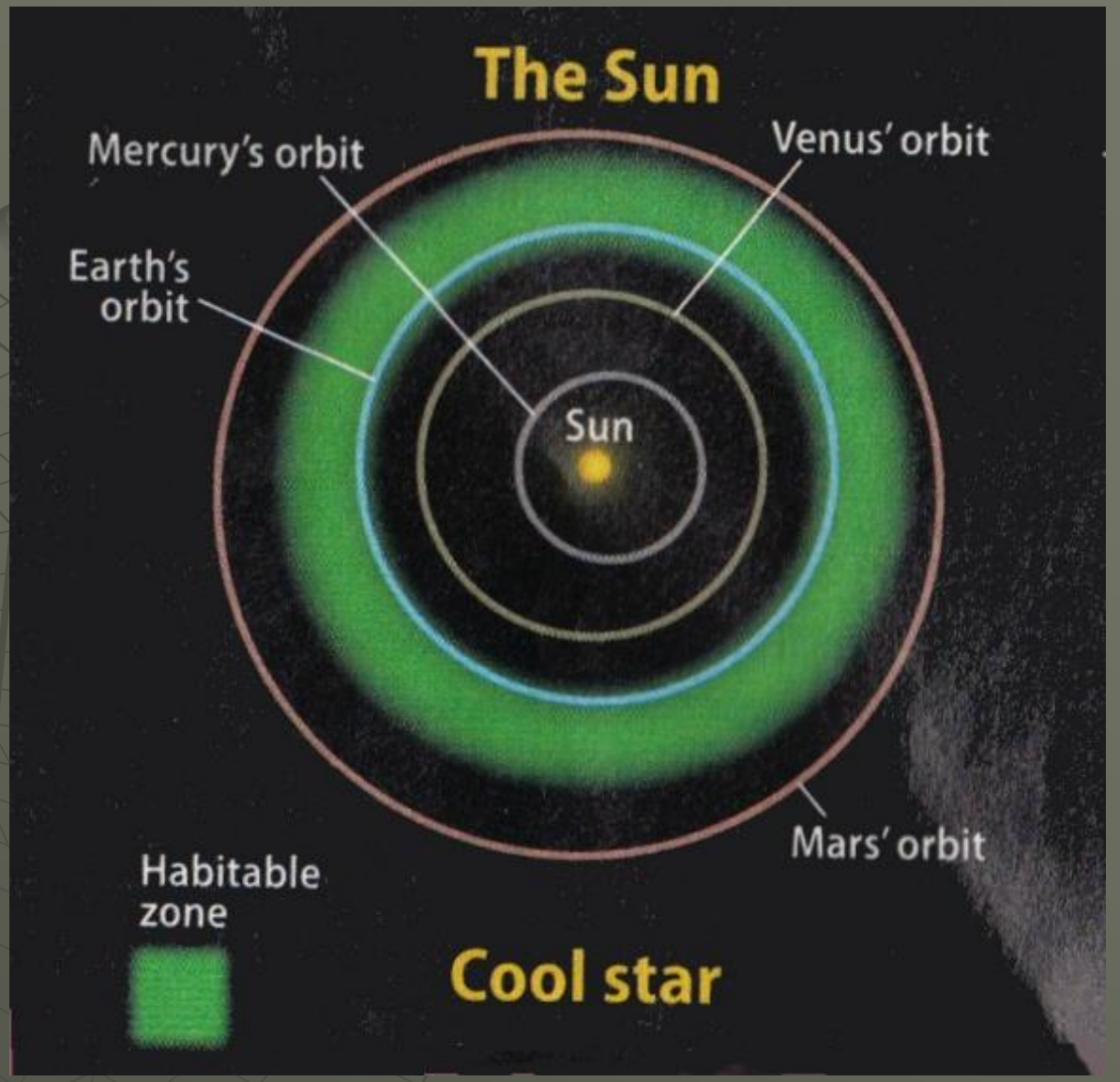
- We have found a handful of **POSSIBLE** habitable planets

- What do we mean by habitable planets?
- Any ideas….

Water

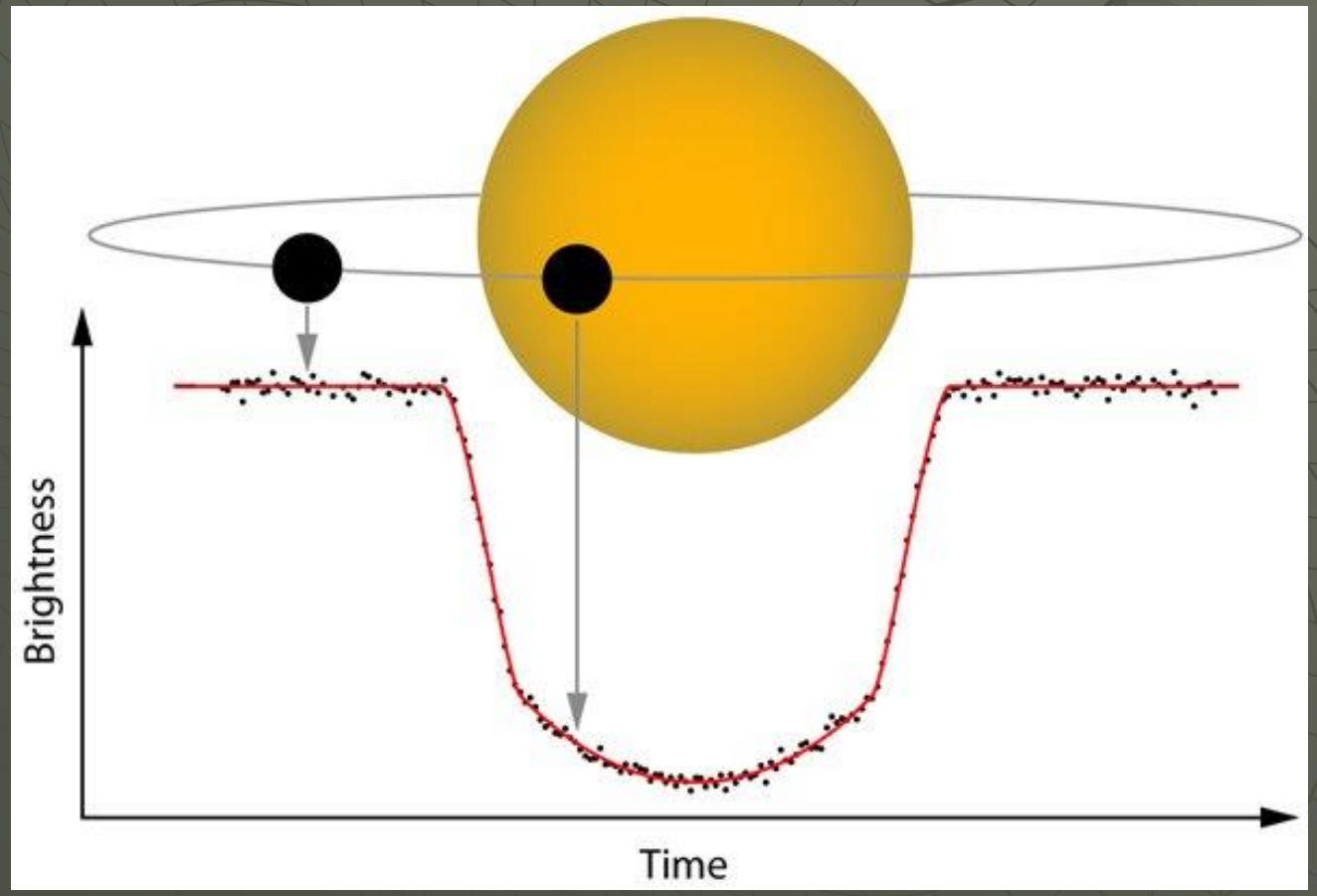
- Need rocky surfaces → high density
- Orbits with temperatures suitable for liquid water
- An atmosphere

- Our solar system →

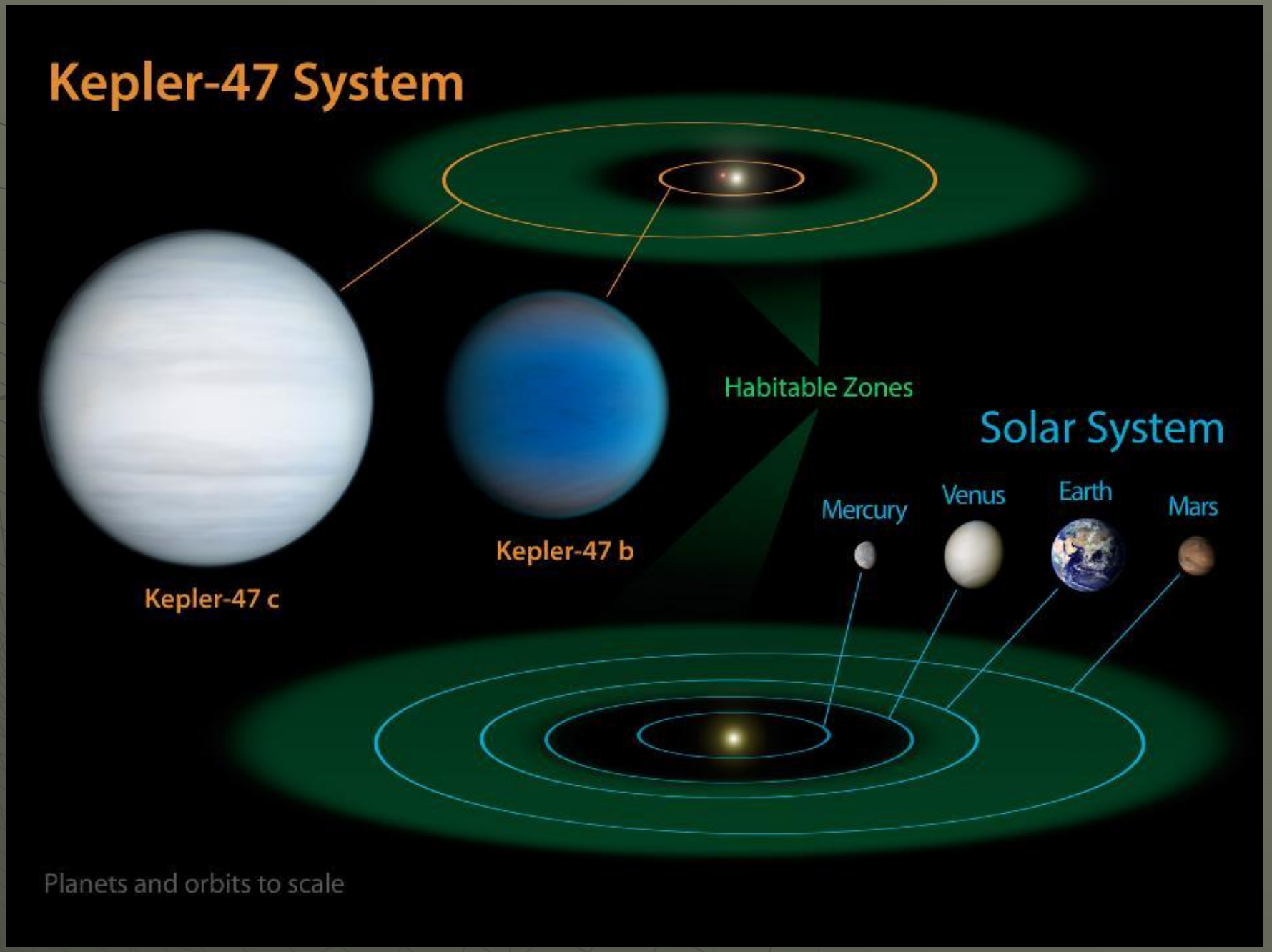


We Need Radius Information!

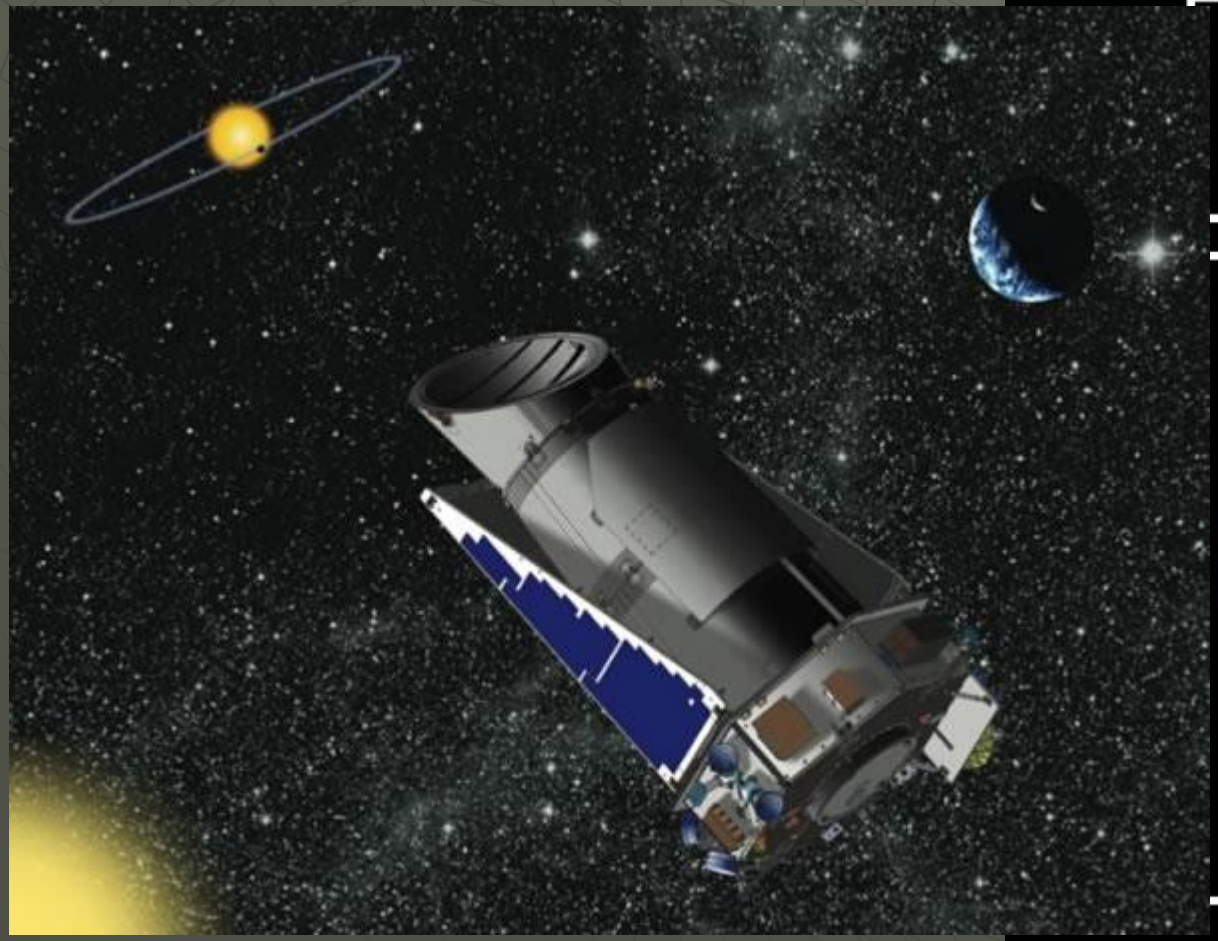
- Second Method of finding Exoplanets: Transits

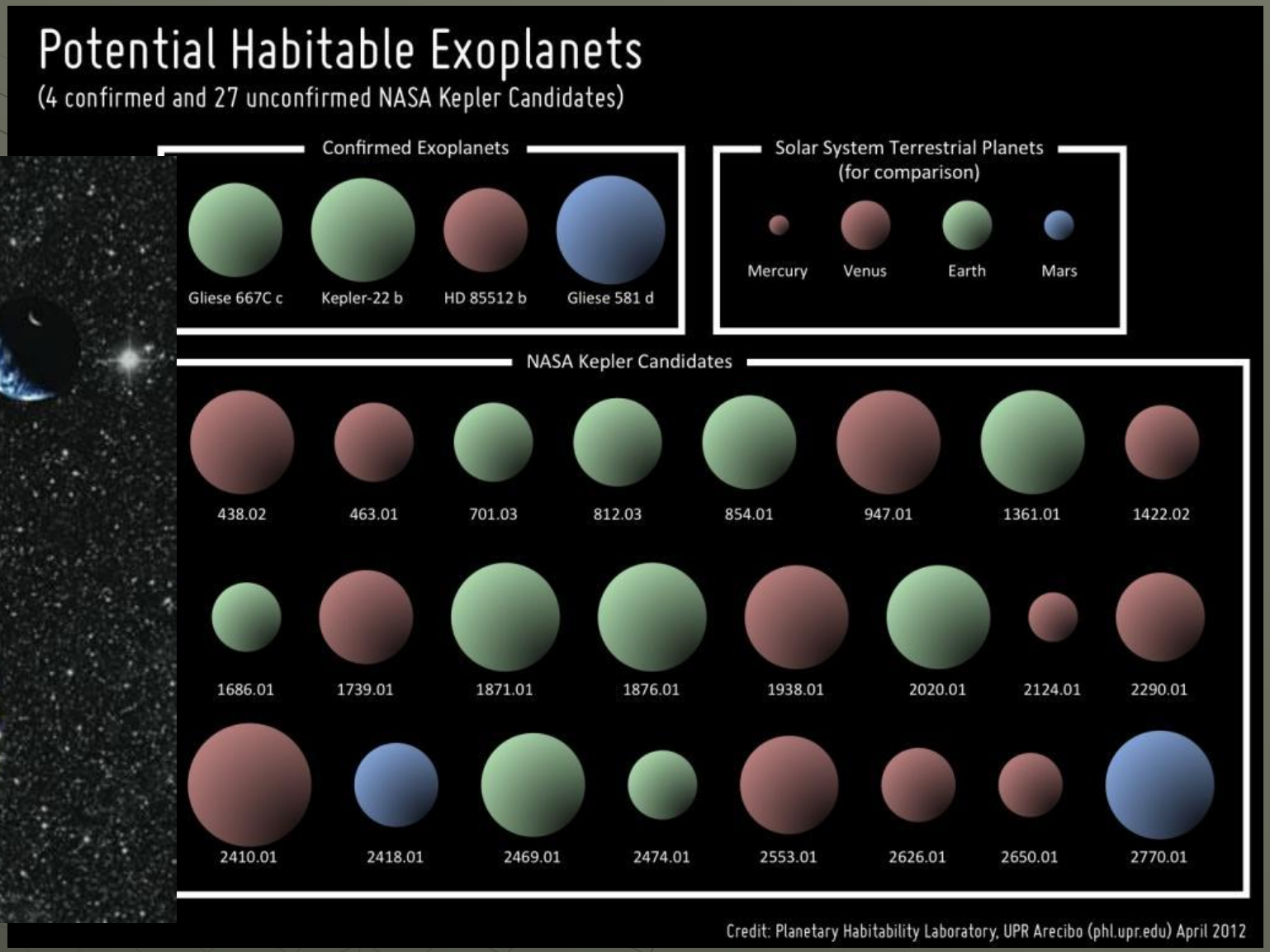


Potential Systems



Kepler Mission






Our Planet
Hunting
Neighborhood
Sun
Most of the planets
found to date lie
within about 300
light-years from
our Sun.

- Is it possible for a nearby star to have a Jovian planet orbiting around it and us not be able to detect it?

A. No, if a nearby star has a Jovian planet, we will detect it.
B. Yes, if the Jovian planet orbits too close to the star
C. Yes, if the Jovian planet orbits perpendicular to our line of sight
D. Yes, if the star is dimmer and less massive than our own Sun