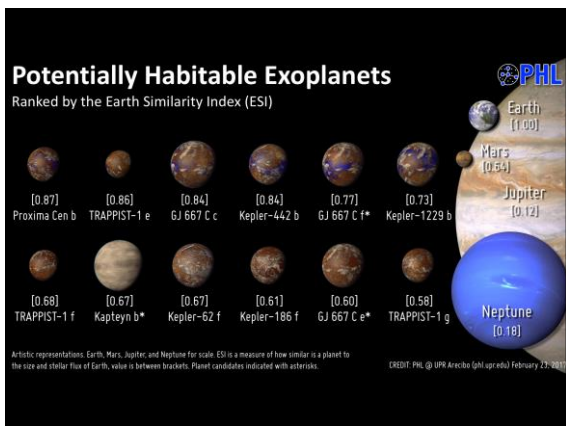


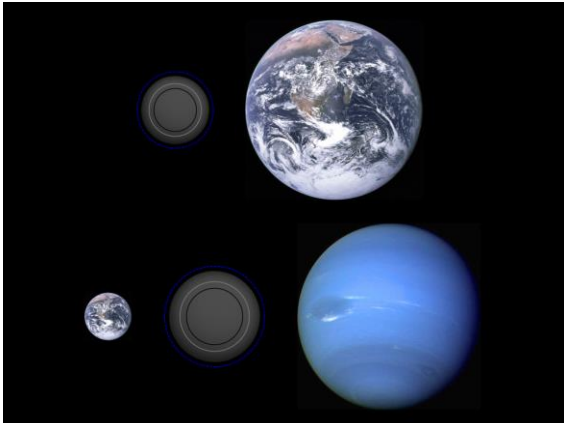
Exoplanets

- **Extrasolar Planets, or Exoplanets,** are planets that orbit stars outside of our solar system.
- As of March 9, 2020, there are **4,135 confirmed exoplanets.**



Discovery:

- Before 1992, the only confirmed planets were in our solar system.
- The first confirmed detection of exoplanets was announced in 1992, with the discovery of two planets orbiting a **pulsar**. Drauger and Poltergeist



Discovery:

- 51 Pegasi b was the first exoplanet to be discovered orbiting a sun-like star by Michel Mayor and Didier Queloz using a ground based telescope in France in 1995.
- They confirmed the planet using the radial-velocity method.

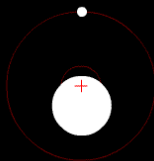
Techniques:

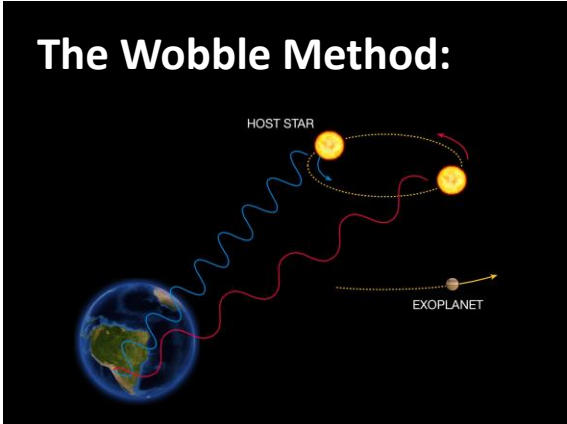
- There are two main techniques used to discover exoplanets.
 - The Radial-Velocity Method
 - The Photometric Method

Techniques:

- **Radial-Velocity Method:** Also called the **'Wobble Method'**, is an indirect method for finding extrasolar planets and brown dwarfs by observing Doppler shifts in the host star's spectrum.

The Wobble Method:





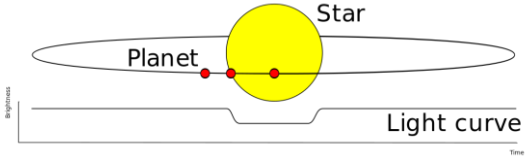
Techniques:

- **Photometric Method:** If a planet crosses (transits) in front of its parent star's disk, then the observed visual brightness of the star drops by a small amount; depending on the relative sizes of the star and the planet.

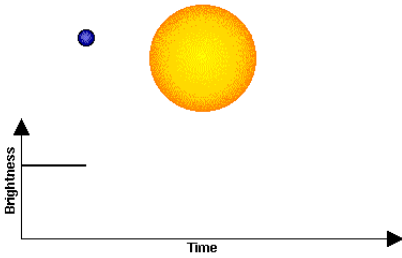
Techniques:

- The photometric method is also referred to as the '**Transit Method**'.
- In order to confirm an exoplanet using the transit method, the dip in a star's brightness must occur at least three times on a scheduled interval.

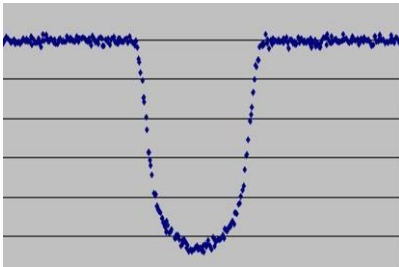
The Transit Method:



The Transit Method:



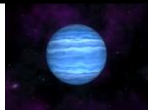
The Transit Method:



Types of Exoplanets:

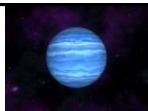
- There are 6 major types of exoplanets that have been discovered:
 - Gas Giants
 - Hot Jupiters
 - Water Worlds
 - Super-Earths
 - Exo-Earths
 - Chthonian Planets

Gas Giants



- **Gas giants** are planets similar to Jupiter, Saturn, Uranus, and Neptune.
- They are mostly composed of hydrogen and helium with possible rocky or icy cores.

Gas Giants



- Gas giants have masses greater than 10 Earth masses.
- Roughly 25 percent of all discovered exoplanets are gas giants

Hot Jupiters

- **Hot Jupiters** are gas giants that either formed very close to their host star or formed farther out and “migrated” inward.
- Hot Jupiters are found within 0.05-0.5 AU of their host star.
- About 50 percent of all discovered exoplanets are Hot Jupiters.

Hot Jupiters

- **Hot Jupiters** can reach surface temperatures as high as 2400 K (4000 °F).



Water Worlds

- **Water worlds** are exoplanets that are completely covered in water.
- Simulations suggest that these planets actually formed from debris rich in ice further from their host star.

Water Worlds

- As they migrated inward, the water melted and covered the planet in a giant ocean.



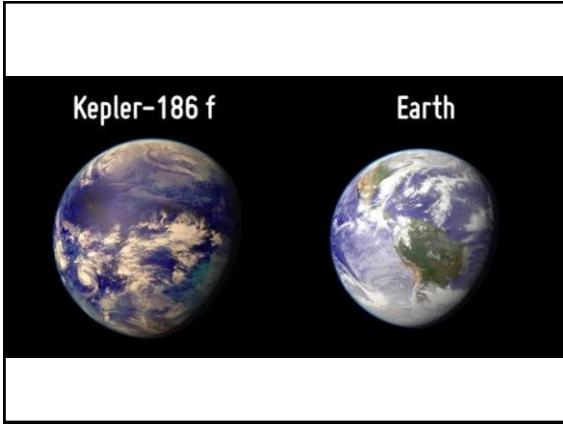
Super-Earths



- **Super-Earths** are potentially rocky planets that have a mass greater than the Earth, but no more than 10 times the mass of the Earth.
- “Super” only refers to the mass of the planet, therefore, some Super-Earths may actually be gas planets.

Exo-Earths

- Exo-Earths are planets just like the Earth. They have a similar mass, radius, and temperature to the Earth, orbiting within the “habitable zone” of their host stars.
- Only a very small number of Exo-Earth candidates have been discovered as they are the hardest type of planet to discover.



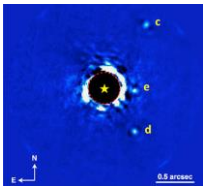
Chthonian Planets



- Chthonian Planets are planets that used to be gas giants but migrated so close to their host star that their atmosphere was stripped away leaving only a rocky core.
- Due to their similarities, some Super Earths may actually be Chthonian Planets.

Directly imaging exoplanets:

- **Adaptive Optics:** Technique used to remove the distortion of light from a star to directly image exoplanets.



The image shows a central yellow star with a dark disk obscuring it. Four small blue dots, labeled 'c', 'e', and 'd', represent directly imaged exoplanets. A compass rose in the bottom left indicates North (N) and East (E). A scale bar in the bottom right is labeled '0.5 arcsec'.

Kepler-7b

