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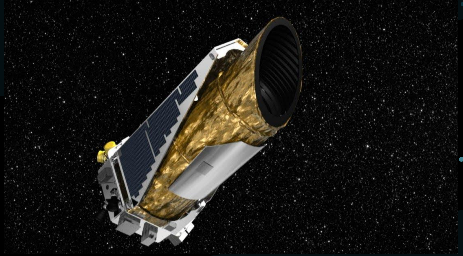
Exoplanets

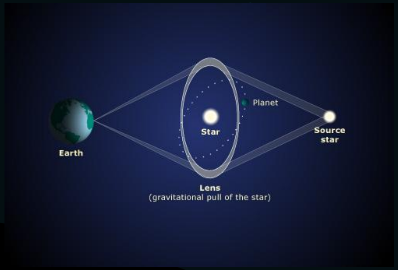
What are exoplanets?

- Any planet beyond our solar system that orbits another star than our sun.
- Most orbit stars, others just orbit the galactic center.
- Located in a small region of the Milky Way.
- Made up of similar elements as planets in our solar system, but mixes differ.
- A lot of different variations of exoplanets (water, frozen, lava, rogue planets, egg-shaped, multiple suns, gas, terrestrial, etc.).
- Come is a variety of sizes and shapes → gas giants (Jupiter, Saturn), small rocky planets (Earth, Mars), egg-shaped, lopsided, etc.

Discoveries



- First discovered in 1995.
- The Kepler Space Telescope helped discover thousands of exoplanets (2600).
- The use of direct imaging (which is used to discover planets of our solar system) does not work as well for discovering exoplanets.
- Discovering Exoplanets happens mostly through indirect methods → Transit method, Examining doppler shifts/Wobble method, Gravitational Microlensing, Astrometry.



Transit Method

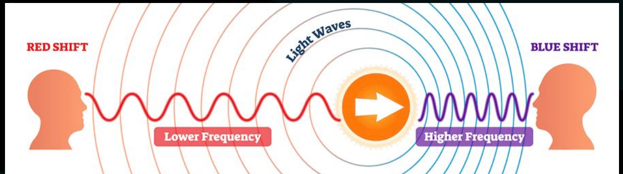
- Measuring the dimming of a star when planet passes in front of it
- Can show planets:
  - Orbit length
  - Radius
  - Chemical composition

Wobble Method

- Monitoring the spectrum of a star for signs of a planet pulling on its star and causing its light to subtly Doppler shift
- Doppler Effect:
  - Higher frequency (blue) → towards Earth
  - Lower frequency (red) → away from Earth

Grav. Microlensing

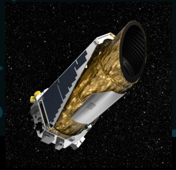
- Foreground star magnifies light from background star, light intensity will spark and will also show a light spark of the orbiting planet



Telescopes

Hubble Telescope

- Pioneer in search for planets
- Been orbiting for 30 years
- Helped make the earliest profiles of Exoplanet atmospheres

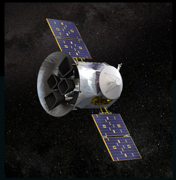


Kepler Space Telescope

- Has discovered thousands of Exoplanets
- Uses Transit Method to discover

Spitzer Telescope

- Captures images of newborn stars
- Discovered TRAPPIST-1 → a solar system of 7 planets like Earth



Transiting Exoplanet Survey Satellite (TESS)

- Finds planets around brighter, closer stars
- Uses Transit Method to discover
- Designed to survey more than 85% of the sky to find Exoplanets

James Webb Space Telescope

- Has a 6.5m mirror → largest telescope sent into space
- Sees the universe in infrared light
- Can see back to nearly the Big Bang (13.6 billion years ago)
- Can reveal details of planetary systems and sample the composition of Exoplanet atmospheres

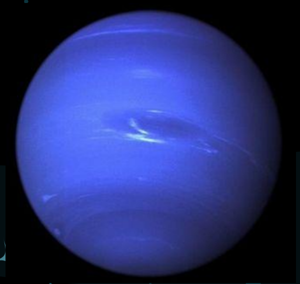
Types of Exoplanets

Gas Giants:

- Size of Saturn and Jupiter, or larger
- Hot Jupiters → very hot planets in close orbit to their stars
- Temperatures of thousands of degrees

Terrestrial Planets:

- Size of Earth, or smaller
- Composed of rock, silicate, carbon or water
- Further investigation needed to discover oceans, atmospheres, life



Neptunian Planets:

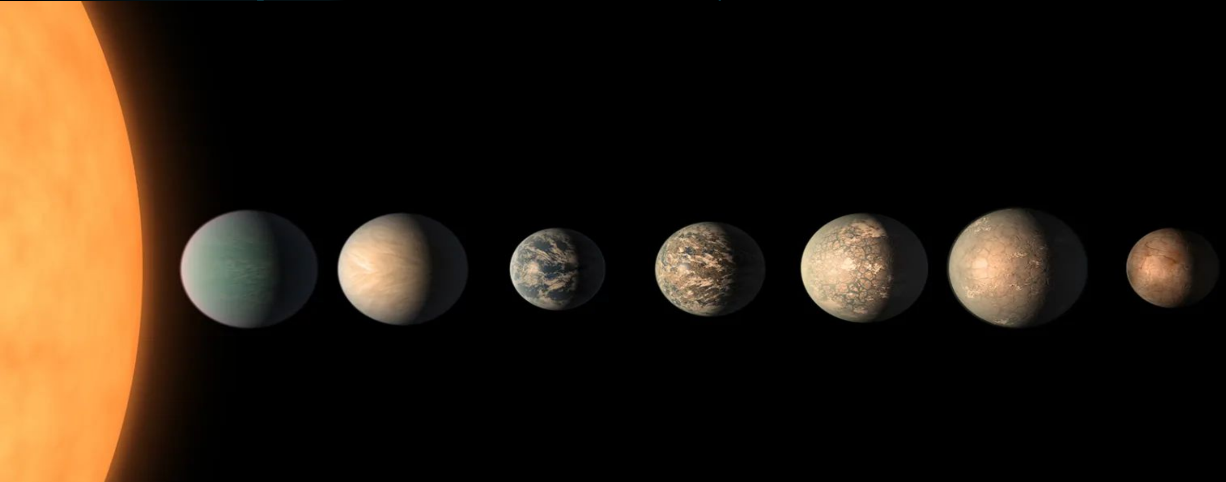
- Size of Neptune and Uranus
- Have Hydrogen and Helium dominated outer atmospheres and rocky cores
- Mini-Neptunes → Planets smaller than Neptune, but bigger than Earth

Super-Earths:

- Terrestrial planets
- Larger than Earth
- Lighter than Neptune
- May or may not have atmospheres

TRAPPIST-1

- The largest batch of Earth-sized exoplanets.
- The most studied planetary system, besides our solar system.
- 40 light years away.
- Have found 7 exoplanets that orbit the TRAPPIST-1 star.



Planets smaller than Earth or similar to Earth's size (such as TRAPPIST-1) are terrestrial, rocky bodies.

The Earth-like planets have potential to hold water and, therefore, life.

TRAPPIST-1 planets are 8% less dense than Earth, so have different chemical compositions.

Exoplanet Stars

- Stars life cycle: nebulae → adulthood → death
- Stars birth:
  - Nebula core heats up as dense packets collapse
  - Spinning clouds of collapsing, heating gas and dust break up into multiple stars
  - Collapsing dust can also turn into planets, moons, asteroids, comets, etc.
- Stars death:
  - Low mass stars turn into red giants and then collapse into white dwarfs (cool, dense stars)
  - High mass stars explode into supernovas, neutron stars, or black holes
  - Each star has a different length of lifetime

Planet formation around stars

Gas and dust that float around a star contain carbon and iron which can form the cores of planets.

Gravity causes materials to collide into a planet, and the planet grows from there.

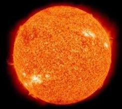
Once the planet starts orbiting their star, it clears material from their path and the star pushes material away, creating a fully formed planet.

Habitable Zones

- Different types of stars have different habitable zones → areas around stars where the conditions are just right for there to be potential life.
- Earth will become uninhabitable in about a billion years .
- There are three types of habitable zone star types:

Sunlike Stars

- Lifetime of about 10 billion years
- Not very common in galaxies
- Large habitable zone



Orange Dwarfs

- Lifetime of about 40 billion years
- Best for advanced life
- More common
- Medium habitable zone

Red Dwarfs

- Lifetime of about 100 billion years
- Very common
- Small habitable zone

Life Elsewhere

NASA is searching for life as we know it, but life elsewhere could be much different than life on Earth → searching for Earth-like planets.

Search for life advanced once Exoplanets were discovered → a lot of Earth-like exoplanets within their stars' habitable zones were found, yet still no life found.

Since our solar system is quite young, it would make sense there is life somewhere else already.

Drake equation aims to find the number of intelligent civilizations in the universe to answer the Fermi paradox which questions why the Earth has not been visited by aliens yet.

Drake Equation: $N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$

What to look for

- Signs of oxygen, carbon dioxide, and methane
- Signs of photosynthesis
- Certain gases or molecules showing animal life
- Atmospheric pollution from intelligent, technological life
- Eavesdrop on extraterrestrial conversations

What is NASA looking for?

- Multiple Earth's → other planets where life could be possible
- Copies of our universe
- NASA's Exoplanet team's ultimate goal is to identify life on other planets than Earth

Why?

Finding whether life exists elsewhere would reveal a lot of details about our place in the universe → where we came from, how life came about, and where we are headed.

How?

Using Transmission Spectroscopy, a star's light shot through the atmosphere of a exoplanet is analyzed as a barcode.

The missing spots of the absorption spectrum will show what elements make up the exoplanet's atmosphere → could indicate life.

My Thoughts

- There is likely life elsewhere.
- Since our solar system is so young, there has been plenty of time for other solar systems to create life.
- There are thousands of Exoplanets that haven't even been found yet and so many ways of analyzing our universe that we haven't discovered yet.
- A lot of Earth-like Exoplanets with similar living conditions and within their stars' habitable zones exist (TRAPPIST-1).
- Some Exoplanets are so different from any planets in our solar system.
- There is no way that Earth is the only place where it worked out perfectly.
- There could also be life unlike Earth's life, that we may not even recognize if we find it.
- Copies of our universe?

THE END

Sources I used:

https://science.nasa.gov/exoplanets/

https://www.skyatnightmagazine.com/space-science/exoplanets-transit-method

https://kids.frontiersin.org/articles/10.3389/frym.2022.857995#:~:text=Due%20to%20the%20Doppler%20effect,(Figure%20revised%20from%20ESO).

https://www.planetary.org/articles/fermi-paradox-drake-equation