How to find Exoplanets: The search for hidden worlds

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WHAT ARE EXOPLANETS, AND WHY FIND THEM?

An exoplanet is **any planet beyond our solar system**. Most exoplanets orbit stars, however so-called 'rogue' planets are untethered to any star, orbiting the **galactic centre** (the point about which a galaxy is rotating). The first discovery of an exoplanet was in **1992** (a planet orbiting a pulsar, which is a dense, rapidly rotating stellar corpse). The first exoplanet orbiting a Sun-like star was discovered 3 years later, in **1995** and was named 51 Pegasi b.

So why should scientists look for exoplanets?
It is important to study exoplanets for many reasons, such as:

- To search for **molecules** associated with **life**, such as methane or liquid water
- To **understand and test laws of physics** in a way that would be impossible on Earth
- To generate and advance our **scientific knowledge**
- To observe characteristics of planetary movement or activity that we cannot yet explain or have **not seen before**

HOW DO WE FIND EXOPLANETS?

There are several different methods for discovering exoplanets, some more successful and efficient than others:

RADIAL VELOCITY METHOD

This method observes the **Doppler effect** of redshift and blueshift (the backwards and forwards motion that appears on the spectrum) that occurs due to the **gravitational pull** from an unseen star. This method has resulted in the discovery of **1027** exoplanets

ASTROMETRY METHOD

This method detects the **'wobble' motion** of a star's position that is induced by a planet on its parent star. As a star is much more massive than a planet, its gravitational pull is most dominant, however the planet also exerts a (weaker) gravitational pull on the star, which causes their **barycentre** (centre of mass) to wobble. Observing this wobble over a period of time could suggest an exoplanet is present. Resulted in the discovery of 2 exoplanets.

TRANSIT METHOD

The transit method focuses on the **dipping magnitude** of a star as an exoplanet **transits** it. The exoplanet blocks out part of its light as it travels in front of the star, hence magnitude decreases. This can be shown in a diagram like the one opposite, where the trough shows the magnitude decreasing whilst the exoplanet transits.

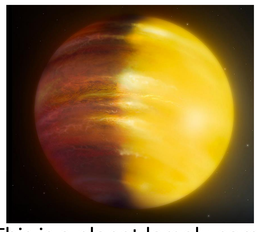
DIRECT IMAGING

This method of discovering exoplanets consists of taking **images of exoplanets** by searching for the light that is emitted from a planet's atmosphere, at **infrared wavelengths**. This is because a star, at these wavelengths, is likely to be about **1 million times brighter** than a planet reflecting light, versus a **billion** times at **other wavelengths**.

RESULTS - WHAT HAVE WE FOUND SO FAR?

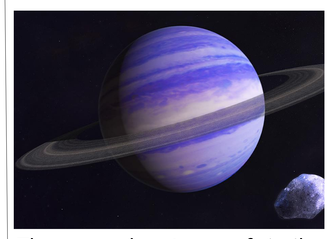
So far, scientists have found four different types of exoplanets: Gas Giants, Neptunians, Super-Earths and Terrestrials.

GAS GIANTS:



This is a planet largely composed of **helium** and **hydrogen**. These exoplanets are similar to Saturn or Jupiter and don't have hard surfaces but a **solid core** surrounded by **swirling gases**. Gas giants that are close to their stars are named 'Hot Jupiters' and these were one of the first exoplanets to be found as they cause pronounced 'wobbling', which can be observed using the **Astrometry** method.
1630 confirmed discoveries
e.g. *51 Pegasi B* or *Kepler-7b*

NEPTUNE-LIKE:

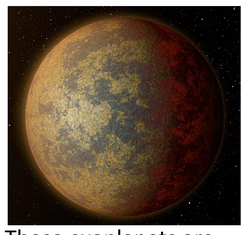


These exoplanets are of similar size to Neptune and Uranus, typically with atmospheres of mostly hydrogen and helium, and cores of **rock** and **heavier metals**. Information about exoplanet atmospheres is often discovered with the help of telescopes such as NASA's **Hubble** and **TESS** (Transiting Exoplanet Survey Satellite). Analysing starlight can help determine the **molecules** in the atmosphere.
1825 confirmed discoveries
e.g. *HAT-P-26b* or *GJ 436 b*

SUPER-EARTH:

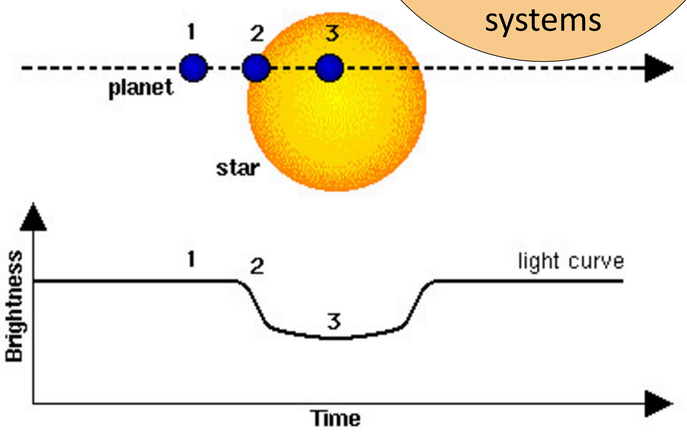
Super-earth exoplanets are **unlike** those in our solar system. Though they are **more massive than Earth**, they are lighter than **ice giants** and compromised of either gas, rock or both. One super-Earth has temperatures that could vaporise metal, while another may be covered in a super ocean!
1595 confirmed discoveries
e.g. *55 Cancri e*

TERRESTRIALS:



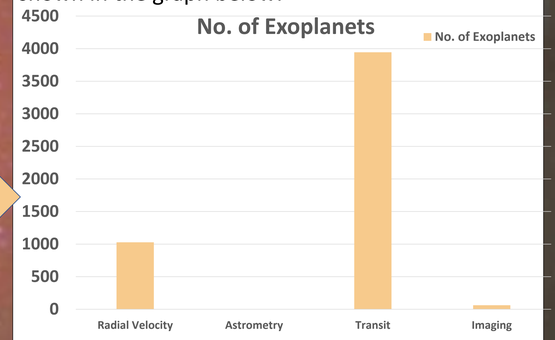
These exoplanets are similar to **Venus**, **Mercury**, **Mars** and **Earth** in our solar system, and exoplanets between **half of Earth's size** to **twice its radius** are considered terrestrial.
195 confirmed discoveries
e.g. *TRAPPIST-1 e* or *TRAPPIST-1 d*

As of 11/02/23, there are **5250** confirmed exoplanets, **9208** Nasa candidates, and **3921** planetary systems



CONCLUSION

Each method for finding and analysing exoplanets have their advantages and disadvantages, and are more suitable in certain scenarios to others. However, the **transit method** has led to the discovery of the most exoplanets (3945 confirmed discoveries out of the 5250 total discoveries – **75.1%**) therefore is currently and statistically the **most successful** method for finding exoplanets, as shown in the graph below:



Nonetheless, all of the methods are valuable and important for the continuous search for exoplanets, helping to expand our scientific knowledge and explore hidden worlds…

AFFILIATED LINKS

https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

https://www.google.com/url?sa=i&url=https%3A%2F%2Fexoplanets.nasa.gov%2F&psig=AOvVaw1JFS3GV3YPzWhOBrtsofEx&ust=1676181263189000&source=images&cd=vfe&ved=0CA0QjhxqFwoTCPic0PnjjP0CFQAAAAAdAAAAABAQ

https://www.eso.org/public/videos/eso0915g/#:~:text=The%20radial%20velocity%20method%20of,an%20(unseen)%20orbiting%20exoplanet.

https://www.google.com/url?sa=i&url=https%3A%2F%2Fexoplanets.nasa.gov%2Fwhat-is-an-exoplanet%2Fplanet-types%2Foverview%2F&psig=AOvVaw1JFS3GV3YPzWhOBrtsofEx&ust=1676181263189000&source=images&cd=vfe&ved=0CAMQjB1qGAoTCPic0PnjjP0CFQAAAAAdAAAAABDCAg

https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

https://physicsfeed.com/post/astrometry-method-detecting-exoplanets/

https://www.universetoday.com/140341/what-is-direct-imaging/#:~:text=As%20the%20name%20would%20suggest,planet's%20atmosphere%20at%20infrared%20wavelengths

https://exoplanets.nasa.gov/what-is-an-exoplanet/planet-types/gas-giant/

IMAGE COURTESY OF ESA