METHODS OF DETECTING MATHODS

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ANNOTATSIYA

This article describes the methods of detecting exoplanets in detail.

Keywords: Exoplanet, Radial velocity, Transit method, direct imaging, Microlensing, Astrometry, Gravitational Wave Detection, 51 Pegasus b, Dimidium.

Astronomy is a happy science: as the French scientist Arago said, it does not need decorations.[1] Exoplanets are one of the jewels of its bosom. An exoplanet is any planet outside the solar system. We are now living in an era where exoplanets are being discovered. This era was opened on October 6, 1995 by Michel Mayor and Didier Queloz announcing the discovery of the first exoplanet. They were awarded the Nobel Prize in 2019 for this important discovery. The first exoplanet is 51 Pegasus b, officially named Dimidium, which is 50 light-years away in the constellation Pegasus. The Nobel laureates fixed Dimidium by removing the radial velocity method. Today, more than 4000 exoplanets have been identified using radial velocity and other exoplanet detection methods. Let’s get acquainted with several methods of detecting exoplanets.

The radial velocity method is a technique used to detect and measure the presence of exoplanets orbiting distant stars. This method involves studying tiny shifts in the spectrum of light emitted by a star, which occur as the star moves slightly back and forth in response to the gravitational pull of an orbiting planet. By analyzing these changes in the star’s radial velocity (the component of its velocity along our line of sight), astronomers can infer the presence and characteristics of the unseen planet. This method has been instrumental in discovering numerous exoplanets and determining their orbital parameters. he radial velocity method is a technique used to detect and measure the presence of exoplanets orbiting distant stars. This method involves studying tiny shifts in the spectrum of light emitted by a star, which occur as the star moves slightly back and forth in response to the gravitational pull of an orbiting planet. By analyzing these changes in the star's radial velocity (the component of its velocity along our line of sight), astronomers can infer the presence and characteristics of the unseen planet. This method has been instrumental in discovering numerous exoplanets and determining their orbital parameters.

The transit method. It involves monitoring the light curve of a star and looking for periodic dips in brightness, which occur when an exoplanet passes in front of the star, blocking some of its light. This method has been very successful in discovering thousands of exoplanets and providing valuable information about their sizes, orbits, and atmosphere. This is the most popular and widely used method and like the radial velocity method, the transit method involves indirectly detecting exoplanets. It is extremely reliable and accounts for more than 70% of exoplanet discoveries. A transit event works like an eclipse; part of the host star's light is blocked when the planet passes in front of the host star, with the observer, the planet, and the host star situated almost in a straight line. In an eclipse, however, the planet passes behind the star.Using photometry, the light curve of the star can be analyzed for a periodic dip in luminosity indicative of a transit. The dimming is only of a small magnitude, with an apparent luminosity decrease of around 1% and 0.001% for Jupiter-sized and Earth-sized planets respectively. The dips are periodic and last only for a few hours. A larger planet creates a deeper light curve compared to a smaller planet due to its ability to block more light(which can be used to determine its diameter), and a transit event lasts longer if its distance from the host star is greater.The structure and composition of planets can be characterized by analyzing the light spectra passing through their atmosphere and have proven successful in detecting elements like methane. The temperature of the planet can also be determined by measuring the intensity of the radiation before and after an eclipse. The Transit method is most effective when surveying a large number of stars at once and also requires a great deal of follow-up observations due to its high rate of false positives. The Kepler Mission hosted by NASA in 2009 used this method to hunt for exoplanets. Most photometry is performed by observatories on Earth that combine telescopes and photometers to detect exoplanets, like the SuperWASP international survey.

Direct Imaging: This method involves capturing images of exoplanets directly. It is challenging because planets are much fainter than their parent stars, and their light can be easily overwhelmed. However, advances in technology have made direct imaging more feasible in recent years.Direct imaging is a challenging method still in its infancy, but with tremendous potential due to its ability to rarely result in false positives. It uses infrared wavelengths to observe large orbits and massive exoplanets that do not transit in front of the star, making it complementary to the radial velocity method. Direct imaging involves taking images of exoplanets directly by blocking the radiation from the host star at infrared wavelengths, when the star is estimated to be only a million times brighter than the planet, compared to a billion times at other wavelengths. The brightness ratio between the planet and the host star is dependent on the size of the planet, the distance between the planet and the star, and the scattering characteristics of the planet's surface.The glare of the star can be removed using coronagraphs which are placed inside telescopes to block light before it reaches the detector of the telescope. Starshades can also be used to prevent light from even entering the telescope. While direct imaging cannot measure the mass of planets, it can aid in answering questions about the potential habitability of a planet by analyzing factors like composition, surface temperature, and diameter using the spectrum obtained. About 100 planets have been discovered using this method, including the Fomalhaut system by the Hubble space telescope and the HR 8799 system by the Keck telescope in 2008.

Microlensing: This method takes advantage of the gravitational lensing effect, where the gravity of a massive object, such as an exoplanet, bends light from a background star. By monitoring the brightness of the star as it magnifies and then fades, astronomers can infer the presence of the exoplanet.Gravitational Microlensing was a result of the prediction of Einstein's General Theory of Relativity, which causes distortion of light and a warp in the fabric of spacetime due to the gravity of a massive body. It incorporates both the gravitational lensing and transit methods and can detect small exoplanets and those found thousands of light-years away. When two stars are almost perfectly aligned, the light of the background star becomes bent due to the gravity of the one in front, which acts as a magnifying glass and results in brightness amplification of the background star by the 'lens' star. This causes the body to appear brighter, with the exoplanets in a system all acting as individual lenses. The entire event appears like a brightening and dimming process that lasts for a short time with a blip in between and is used by astronomers to obtain information about planet formation and evolution. Follow-up confirmations of lensing events are almost impossible since they occur in a rare and random fashion, and only rough data about the planet's distance can be obtained.

Astrometry: This method involves measuring the position of a star relative to its background stars. If the star wobbles back and forth slightly, it can indicate the presence of an exoplanet.Astrometry is a challenging method and requires precise measurements over an extended perioAstrometry.This is the oldest method used in the discovery of extrasolar planets and is highly sensitive. The wobble of stars is detected through changes in the star's apparent position in the sky, as opposed to the Doppler effect used in the radial velocity method.Images are taken of the host star and reference stars in close proximity to it, and these are analyzed at regular intervals by measuring the distance between the target and reference stars. It requires extreme precision but can provide an accurate estimate of the planet's mass and is best suited for planets with larger orbits. The accuracy of this method is limited by the formation of starspots and observation time needs to extend for multiple orbital periods.

Gravitational Wave Detection: This method looks for gravitational waves, which are ripples in the fabric of spacetime caused by massive objects in motion. Although indirect, the detection of gravitational waves can provide evidence for the presence of exoplanets.

It's important to note that different methods are more effective for detecting different types of exoplanets. Astronomers often use a combination of these methods to confirm the existence of exoplanets and learn more about their properties.

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