Feature Article

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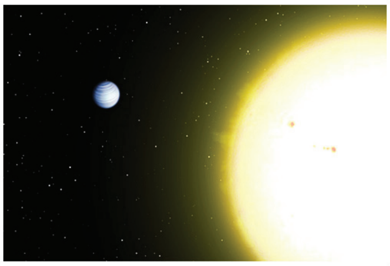
Vivi is a writer and educator, with a keen interest in social science, philosophy, art, archaeology and history. She is involved extensively with astronomy communication to the public, enjoying the challenge of conveying complex ideas in an easy-to-understand manner.

We have long wondered whether there could be planets orbiting the countless stars we see in the night sky. This is a voyage of discovery for astronomers whose scientific search began to bear fruit when the first extrasolar planets were found in the early 1990s. This article explains about the history of planet hunting, and the methods of finding them.

Exoplanets: the quest to find other worlds

In this gigantic Universe, the law of probability suggests that we should find other solar systems. So the question emerges: could we find other planets?



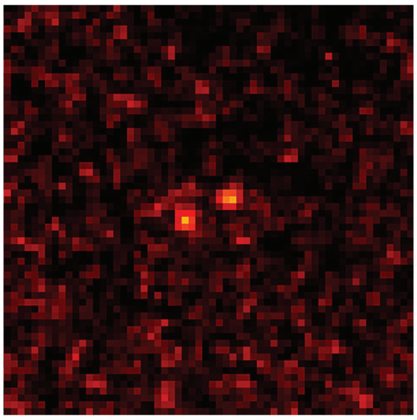
An artist's impression of the star 51 Pegasi, and the exoplanet orbiting it.
Image credit: Debivort.

The search begins!

In the early 1990s, after years of looking, the first planet outside our Solar System was discovered. This exoplanet was discovered by Aleksander Wolszczan and Dale Frail around a pulsar in the constellation Virgo. This discovery surprised astronomers. Why? Well that's because astronomers used to think that planets would only be found around stars similar to our Sun.

Then in 1995, a planet was found by Michel Mayor and Didier Queloz orbiting a star like our Sun, named 51 Pegasi in the constellation Pegasus. This was the first planet discovered close to a star just like our own.

Since these finds, exoplanets have been rapidly located due to technological advances that give us the possibility to find them indirectly. To date, 344 exoplanets have been discovered with 37 multiple-planet-systems among them. However, none of them is a new Earth. And most of these planets have never been seen by the observer; they have been discovered using indirect methods. So, what does indirect observation mean? Is it impossible for astronomers to ever actually touch the objects they study?



Direct imaging of exoplanets is possible with existing technology, but not much detail can be seen!
Image credit: NASA, ESA and P. Kalas (University of California, Berkeley, USA).

That's true, in the astronomy world we can't touch objects like stars with our hands. But we can observe directly with telescopes. We can easily spot planets like Mars or Jupiter, or stars like Sirius or Betelgeuse. And yes, there have several planets found directly, such as an exoplanet discovered by the Hubble Space Telescope around Fomalhaut, or multiple planets around HR 8799 using telescopes at both Keck Observatory and Gemini Observatory. But only a few have been found directly. Most others are difficult to see from Earth. And this is the reason why:

The stars we see in the night sky appear to us as single pin-pricks of light. How do you spot planets around them, which are tiny and dim in comparison, if even the bright stars look like point-sources? This is the challenge! Furthermore, planets don't produce light of their own. And, just like their parent stars, these exoplanets reside at enormous distances from us. With the stars shining, the planets are lost in the glare. As observers we can only see the stars, so how can we find the planets? Well, we look for changes in the stars' behavior, like getting slightly brighter or dimmer. This is what astronomers mean by indirect methods: searching for exoplanets by looking for changes in the stars. Just what are these methods?

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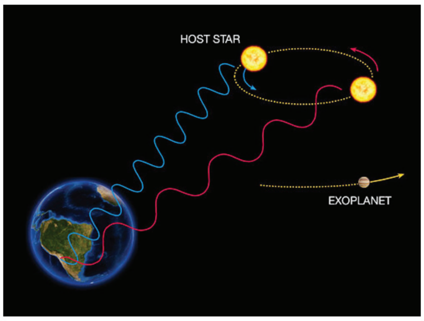
Radial velocity: wobbles in space

The most productive technique is the radial velocity method. It is also known as the Doppler effect. With this, we can measure variations in radial velocity of the stars when both star and planet revolve around their common centre of mass. The planet's gravitational tug will induce the star to move, causing a wobble. When both of them move about their centre of mass, the star's velocity will change slightly. It looks like a dancing star, moving towards and away from the observer. This phenomenon can be detected by analysing the star's spectrum. It's like an ambulance's siren changing as it moves toward and then away from you. The larger the planet and the closer it is to the star, the faster the star will move and the greater the shift in the spectrum.



Detection of exoplanets using the radial velocity method. The starlight moving toward Earth will be bluer and when the light moves away it will be redder.
Image credit: ESO.

Astrometry: measuring the position of the stars

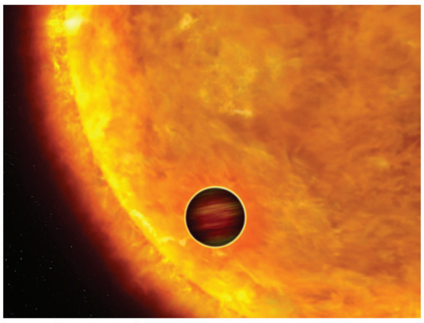
Another similar method is astrometry. This measures the difference in the star's position that is caused by an orbiting planet. However, the changes are really tiny and it is even more difficult to find a planet with this method.

Transit: looking for mosquitoes crossing a distant lamp

Another way to find exoplanets is with the transit method. This detects the brightness changes in a star with a companion. When a planet passes in front of a star, it will block a small portion and cause a reduction in the star's brightness. With a sensitive instrument we can detect this reduction in brightness periodically as a planet passes in front of the star. However, this method can only detect planets close to their parent star.

Gravitational microlensing: lenses in space

When a planet passes in front of a host star along our line of sight, the planet's gravity behaves like a lens. This focuses the light rays and causes a temporary sharp increase in the star's brightness. It also causes a change in the apparent position of the star.



A transit is when a planet passes in front of a star. When this happens, we can see the star's brightness dip temporarily.
Image credit: NASA, ESA and G. Bacon.

Pulsar timing: searching for anomalies in a pulse

Pulsars are magnetised rotating neutron stars that emit radio waves and appear like radio pulses for observers on Earth. Slight changes in pulsar timings will be recognised by the observer. If this happens, we can track pulsar motions to work out if there is a planet orbiting the pulsar, or if there is something else making the changes.

Next stop: exoplanets like our own

Most of the planets detected so far by astronomers are gas giant-size and super Earth-size. One day, maybe we will find planets like our own orbiting another star. In fact, the Kepler mission was launched in March 2009. It will detect exoplanets using the transit method and show us if Earth-like planets are common in the Universe.

This feature article was written as part of the Cosmic Diary Cornerstone project for the International Year of Astronomy 2009. To find out more, check out www.cosmicdiary.org and www.astronomy2009.org.