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Half Beninese, half Belgian, Aude jumps at any chance to share her experiences with other people. And she has lots to discuss, having studied for many years in both France and the United Kingdom. Her specialty is astrophysics, and she is currently pursuing a PhD in the subject.

It's one of humanity's ultimate questions: are there other planets out in the depths of space, beyond our own Solar System? Thanks to new technology and ingenious astronomers, we now know that there are indeed countless worlds in our Galaxy and beyond. But as they are so far away, how can we know for sure that they are really there? And can we see what it's like on these far-flung worlds? Read on for the answers!

Other Planets in Our Galaxy

"Are we alone in the Universe?" is a question we all wonder. We now know that there are no other planets like the Earth in our Solar System, so astronomers have extended their search to stars other than the Sun. These planets are called exoplanets.

Needle in a haystack

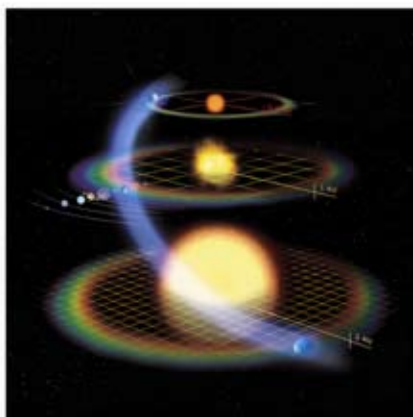
Trying to detect exoplanets is a challenging task. Unlike the nearby planets in our Solar System, exoplanets are very difficult to observe directly. Planets are millions of times fainter than their star, and seen from hundreds of light years away - a light year is a year travelling at the speed of light, which is more than a million times faster than an aeroplane! - they appear so close to their star that they are hidden away from us in the glare. So far only four exoplanets have been directly imaged using careful techniques cancelling out the light from the star to see fainter object in closer orbit. These planets, first published in November 2008, are bigger than Jupiter and in large orbits.

Scientists have developed several other methods to detect exoplanets. Instead of trying to see the planet directly, these methods aim at detecting the planet indirectly, such as through its influence on its star or on stars far away behind it.

The snappily named 51Pegasi b, found in 1995, was the first discovery of a planet around a star similar to the Sun. This exoplanet was discovered by Suisse astronomers using the "radial velocity method". 51Pegasi b is a planet more than 150 times as massive as the Earth - about half the mass of Jupiter - and 20 times closer to its star than the Earth is to the Sun. It would take us 50 years travelling at the speed of light to reach it.



So far, astronomers have mostly found large planets around other stars, such as in this artist's impression. Image credit: NASA, ESA, and G. Bacon (STScI).



The "habitable zone" around a star is where water can exist as a liquid on a planet's surface. This exact distance depends on the star.
Image credit: ESA 2001. Illustration by Medialab.

When a planet orbits a star, it causes the star to also move in a small orbit of its own. The "radial velocity method" consists of measuring the speed at which the star moves towards and away from us due to a planet orbiting around it. This speed is called the "radial velocity" and is only a few kilometres per hour for small planets like the Earth, about the speed at which we walk. It is measured by studying features in the light coming from the star. With this method, scientists can measure the minimum mass of an exoplanet. So far, more than 200 exoplanets have been discovered with this method, making it the most popular technique. Other successful systems include "transit", and "microlensing".

Which type of exoplanets have we found so far?

Since 51 Pegasi b, astronomers have found more than 300 exoplanets in our Galaxy, with new ones being discovered every month. Small planets like the Earth are extremely challenging to detect, as the smaller the exoplanet the weaker its signal. None found so far resemble the Earth in terms of composition or habitability. Most of them are more massive than Jupiter, meaning that they are very different from the Earth. They are also closer to their star than Mercury is to the Sun, meaning that it is extremely hot on their surfaces, more than 10 times hotter than boiling water! These exoplanets are nicknamed "hot Jupiters".



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Among all the exoplanets discovered so far, the one that could resemble the Earth most is perhaps Gliese 581 d. Gliese 581 is a star three times smaller than the Sun, 20 light-years away from us. Gliese 581 d is the third planet around this star, orbiting slightly closer to its star than the Earth does around the Sun. Its mass is expected to be more than eight times that of the Earth, but its exact mass and radius are still unknown. This means that, for now, it is impossible to know what Gliese 581 d is made of.

How much can we know about these exoplanets?

With our current technology, astrophysicists can already do a lot of great science, using ingenious scientific techniques to stretch the performance of available instruments. With the right observations, astrophysics can measure the mass and radius of an exoplanet, the shape of its orbit, and have a rough idea of its composition and atmosphere. The mass and radius of an exoplanet are used to calculate the planet's density, which gives some information on the composition. The shape of the orbit of an exoplanet gives some information on the temperature and how it might have formed.

Detecting the atmosphere of an exoplanet was meant to be achievable only with the next generation of space telescopes, but clever astrophysicists have developed ingenious methods with the current orbiting observatories Hubble and Spitzer. Detecting the atmosphere of an exoplanet can currently be achieved for transiting planets in two ways. The first is by studying the light from the star that passes through the planet's atmosphere. The other way is by studying the light from the exoplanet itself by measuring the difference between the light received from both the star and the planet and the light received from only the star when the planet disappears behind it.

In some cases astrophysicists can even detect brightness variations as the planet moves around its orbit. These give some information on the presence of clouds in the atmosphere and atmospheric circulation of the exoplanet. We are actually starting to study some kind of "weather" on these worlds!



During a transit, a planet passes in front of its star as seen from the Earth, meaning that we see the star's brightness dim a little. The dark spot in this picture is actually the planet Mercury, during a transit of our own Sun.
Image credit: Hinode JAXA/NASA/PPARC.



High-tech instruments like the NASA / ESA Hubble Space Telescope are vital tools for astronomers seeking distant exoplanets.
Image credit: ESA.

What's next?

The next generation of space telescopes, Darwin (launch after 2015) and Terrestrial Planet Finder (launch after 2020), are designed to find and study habitable exoplanets with direct imaging. With these telescopes, scientists hope to discover worlds resembling the Earth, and look for chemical signatures of life in the atmosphere of these planets.

Finding and studying exoplanets is really exciting science. It helps us understand how our Solar System was formed and what our place is in the Universe. It is a scientific way of looking for answers to questions such as "are there other planets like the Earth in the Universe?" and "is there life on these planets?"

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.