In search of new Earths and life in the Universe

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Twenty years ago, in Geneva, PhD student Didier Queloz discovered a planet orbiting another sun – something that astronomers had predicted, but never found. Today he continues his terra hunting for extreme worlds and Earth twins in Cambridge.

When the numbers began to filter through from the spectrograph that was measuring small shifts in light from distant stars, Didier Queloz at first thought they were wrong. He certainly didn't think he'd discovered an exoplanet. He checked and re-checked.

"At some point I realised the only explanation could be that the numbers were right."

Today, many regard the discovery of 51 Pegasi b by Queloz and Professor Michel Mayor at the University of Geneva in 1995 as a moment in astronomy that forever changed the way we understand the universe and our place within it. It was the first confirmation of an exoplanet – a planet that orbits a star other than our Sun. Until then, although astronomers had speculated as to the existence of these distant worlds, no planet other than those in our own solar system had ever been found.

"For centuries, we only had the one single example of our own solar system on which to base our knowledge of planets," says Queloz, who moved to Cambridge's Department of Physics two years ago. "If you wanted to understand botany, you wouldn't build the botanic picture from one single flower – you need all the others."

Of the 1,900 or so confirmed exoplanets that have now been found – a tenth of these by Queloz himself – many are different to anything we ever imagined, challenging existing theories of planet formation.

Fifty light years from Earth, the exoplanet 51 Peg resembles the gas giant Jupiter. But unlike our distant cousin, which is located in the further reaches of our solar system and takes 10 years to orbit the Sun, 51 Peg 'hugs' its sun, orbiting every four days. It's been hailed as an example of a whole new class of 'roaster planets' or 'Hot Jupiters' and has prompted scientists to wonder if large planets are able to migrate closer to their suns over millions of years.

"We are constantly surprised by the diversity of the other worlds," says Queloz. Super-Earths like the volcanic planet 55 Cancri e with a temperature gradient across it of a thousand degrees; rogue planets like

PSO J318.5-22, which roam freely between stars; Kepler-186f, which is lit by the light of a red star; and icy Kepler-16b with its double sunset. "For some, we don't even have names to describe what they are."

But, as yet, no planet has been discovered that could be considered a twin of our own. "We are finding planets of a similar size and mass to Earth but nothing at the right temperature – so-called Goldilocks planetary systems in the habitable zone close enough to the sun to be warmed by it but not so close that the presence of water and life is a sheer impossibility," explains Queloz.

"Of course the question everyone would like to answer is whether there is life out there, because we are curious and we can't resist – it's how we are," says Queloz.

Queloz believes that a new era of terra hunting is fast approaching. "The past 20 years has seen a 'brute force' hunt for exoplanets. We are now confident that they are practically everywhere you look for them. To find an Earth twin, however, we need to look at specific planets for longer."

It's not possible to see an exoplanet directly – it's far too close to a blinding source of light, its star – so astronomers use two techniques to look indirectly. Focusing on a star, they use NASA's Kepler telescope to look for the dimming of starlight as the planet transits in front of it. From this, they calculate the planet's size and temperature.

The breakthrough that Queloz and Mayor pioneered was a technique to look for signs of 'wobble' caused by the gravitational pull exerted by the planet on the star as it orbits. The technique needed to be accurate enough to detect a wobble of only 10 m/s – the speed of a running man. To put this in context, the Earth moves at the speed of 30,000 m/s."

Current technology works well for finding large exoplanets but to find planets the size of the Earth in the habitable zone astronomers need to look at smaller stars, and they need to overcome 'stellar noise', or natural variability in the data caused by physical motions of gas at the surface of the star.

"This noise is slowing further progress but we believe that it can be overcome by careful analysis and by extending the length of time we are able to observe a planet for," adds Queloz. "Intensive runs on a small number of stars where an observation is carried out every night for years is far more valuable than unevenly spaced data taken over years."

As techniques improve and with the launch of NASA's James Webb

Space Telescope, astronomers will be able to ask whether what we understand as the basic molecules of life – carbon, oxygen and hydrogen – are present in the atmosphere of exoplanets, opening up the possibility of understanding their astrobiology and geophysics.

"My feeling is that life will be found, although life like us may be extremely rare because otherwise we probably would have seen it by now," he adds. "It may take a long time, and many scientists, to find life, but maybe that's part of the fun – it would be too easy otherwise!"

On the door of Queloz's office is a spoof poster published by NASA in celebration of 20 years of exoplanet discoveries. Offering greetings from the Exoplanet Travel Bureau, it suggests 51 Pegasi b as a dream destination, or indeed "any planet you wish – as long as it's far beyond our solar system." Could this be reality one day? "It's far too hard to say," says Queloz. "But I would hope that sending a tiny probe of perhaps a few grams in weight might be possible in the next century."

At one stage in recent years, Queloz was almost finding an exoplanet a week. His terra hunting has slowed while he focuses on improving the equipment and techniques that he believes will help find an Earth twin. But the excitement never goes away, he says. "I must admit that every time I find a planet I feel like a child – it's a surprise because it's a new system. I used to joke with people asking me about sci-fi – the reality is far more exciting and diverse than any sci-fi movie you can imagine!"

Provided by University of Cambridge

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