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The tools needed to seek out new worlds in space

January 13 2015, by Jonti Horner, Belinda Nicholson And Brad Carter

Artist's impression of the planet Kepler 62-f which could lie in the habitable zone of its host star 1,200 light-years from Earth in the constellation Lyra. Credit: NASA Ames/JPL-Caltech

More than 1,000 exoplanets have now been discovered by the Kepler Space Telescope, announced NASA this month, and the figure continues to climb.

Three of the newly confirmed Kepler planets are thought to lie in the habitable zones of their host stars and are only slightly larger than the Earth.

But the planets found by Kepler are too distant for us to follow them up and characterise them in great depth – so while Kepler gives us a feel for how common are planets like the Earth, the search for life must wait for future discoveries.

A growing catalogue of planets

In the two decades since the first exoplanet was confirmed orbiting a sun-like star (51 Pegasi b), more than 1,500 exoplanets have been found. The number grows ever more rapidly, a result of both improvements in how we search and the length of time we have been looking.

The two main techniques by which we detect exoplanets both rely on observations of periodic behaviours of their host that can only be reasonably explained as the result of unseen planetary companions.

That periodic behaviour is linked to the orbital period of the planet – the host star will only wobble or wink at the frequency at which its planet orbits.

Over the two decades since the first exoplanets were discovered, new technology and improved observational techniques have helped astronomers find more new worlds. This is exemplified by the space-based Kepler mission and its discoveries, which account for two-thirds of the known exoplanet total.

On top of this, Kepler has more than 4,175 candidate exoplanets that await sufficient follow-up observations to be confirmed.

A second life for Kepler

When the second of the Kepler's four gyroscope-like reaction wheels failed in May 2013, the first phase of its observing program came to an end.

With only two working reaction wheels, Kepler is no longer able to point continuously at a single part of space.

But by clever use of the two remaining reaction wheels, the telescope has been reorientated so that it now looks in the plane of our solar system. As a result, it is now performing the K2 mission, known as Second Light .

This program will uncover a wealth of new planets, all moving on short-period orbits around their host star. While it is highly unlikely that many will be habitable, this data will be invaluable for astronomers attempting to fully understand how planets form and evolve.

In addition, the K2 mission will also yield new discoveries, ranging from previously unseen solar system objects to supernovae in distant galaxies.

So, aside from Kepler, what other tools are in the pipeline to help us find more exoplanets and to search for life elsewhere in the universe?

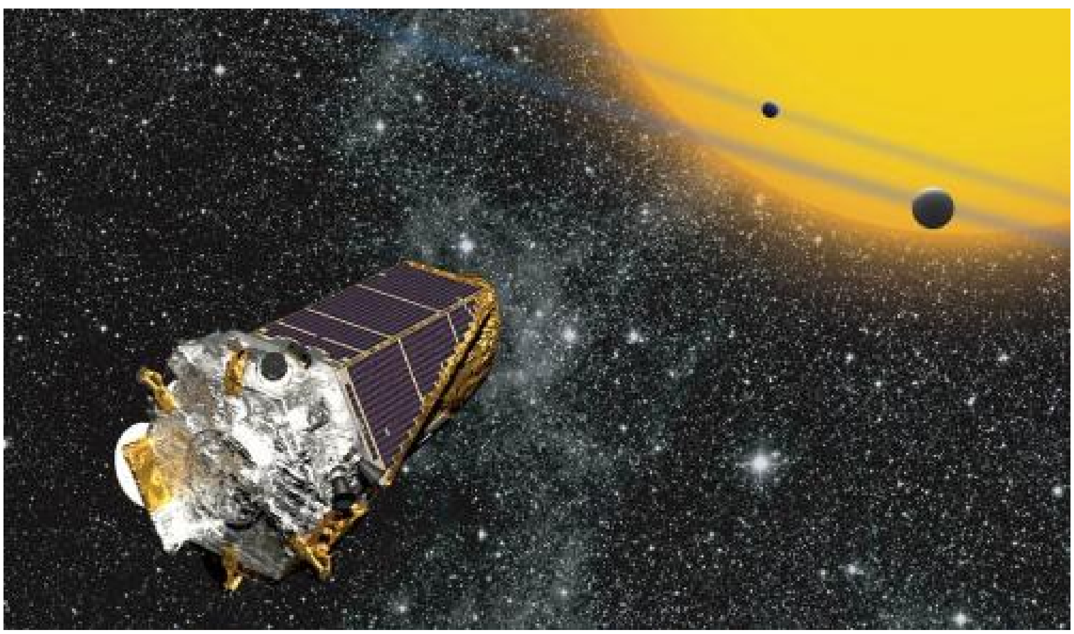
Minerva – operational now

The Minerva observatory, based at Mt Hopkins in the United States, is custom-made with the goal of detecting Earth-like planets around nearby stars. It will even be capable of discovering "super-Earths" in the habitable zone of the closest sun-like stars.

Minerva is an array of four robotic telescopes capable of both taking detailed spectra of bright stars (to look for the tell-tale wobble of accompanying planets) and carrying out photometry (measuring with exquisite precision the brightness of those stars, to follow up on exoplanet transit discoveries).

The beauty of Minerva is that, like Kepler, it is a dedicated instrument – one that will observe on every single clear night with the single goal of detecting and characterising new planets. In addition, it is a project in which Australia is directly involved, through the purchase of the fourth telescope in the array.

While Kepler's K2 mission will discover hundreds, if not thousands, of new worlds, Minerva's output will be far more modest, yielding just tens of exoplanets. But those exoplanets will be close enough to follow up in great detail, a great boon for scientists trying to find habitable worlds.



Artist’s impression of the Kepler Space Telescope, discovering new planets transiting a distant star. Credit: NASA Ames/ W Stenzel

Gaia spacecraft – operational now

In December 2013 the European Space Agency launched the Gaia spacecraft. Its five-year goal is to precisely measure the locations, distances and in-space motions of the nearest ~1 billion stars – a monumental task.

To do this, Gaia will repeatedly measure the position of each of those stars, to a precision never before achieved.

In addition to creating a magnificent 3D map of almost 1% of the stars in our galaxy, Gaia's observations will be of such quality that it should detect tens of thousands of new exoplanets, as a result of the wobble they induce in their host stars.

Watching those stars rock back and forth will greatly boost the number of known exoplanets, but the majority will be so distant as to be beyond our reach, in terms of the search for life.

But Gaia will not just study distant stars. It could easily find potentially habitable worlds around stars in our own backyard!

Transiting Exoplanet Survey Satellite (TSSS) – August 2017

The successor to Kepler, NASA's TESS mission will again make use of the transit method of exoplanet detection. But unlike Kepler, TESS will focus on the brightest nearby stars, in a whole-sky survey using an array of wide-field cameras.

The goal of TESS is to find Earth-like planets in the habitable zones of stars sufficiently close that the next generation of telescopes (such as the James Webb Space Telescope and the giant telescopes being built as we speak on Earth) could characterise them and potentially search them for the signs of life.

TESS aims to target around half-a-million stars and is expected to discover thousands of transiting planets, down to the size of the Earth, and beyond. Since TESS will be targeting bright stars, it will be possible to follow up its discoveries using ground-based facilities, which should greatly speed the conversion of candidate planets to confirmed discoveries.

James Webb Space Telescope (JWST) – late 2018

Often labelled as NASA's successor to the hugely successful Hubble and Spitzer Space Telescopes, the JWST's development has been beset by problems that have significantly delayed its launch from 2011 to 2018.

Once it does launch, JWST will feature a mirror almost three times the diameter of Hubble's, cooled to be highly sensitive to infra-red light. It might be just the tool scientists need to characterise Earth-like planets around other stars.

Giant Magellan Telescope (GMT) – to be completed in 2020

The Giant Magellan Telescope is another project in which Australia is heavily involved. The first of the next generation of gigantic telescopes, the GMT will be located in Chile, at the Las Campanas Observatory.

It will feature a mirror more than 25 metres in diameter, with a light-collecting area far greater than any optical telescope that came before.

With such an enormous light grasp, the GMT will be able to do revolutionary observational work including searching for and characterising planets like our own.

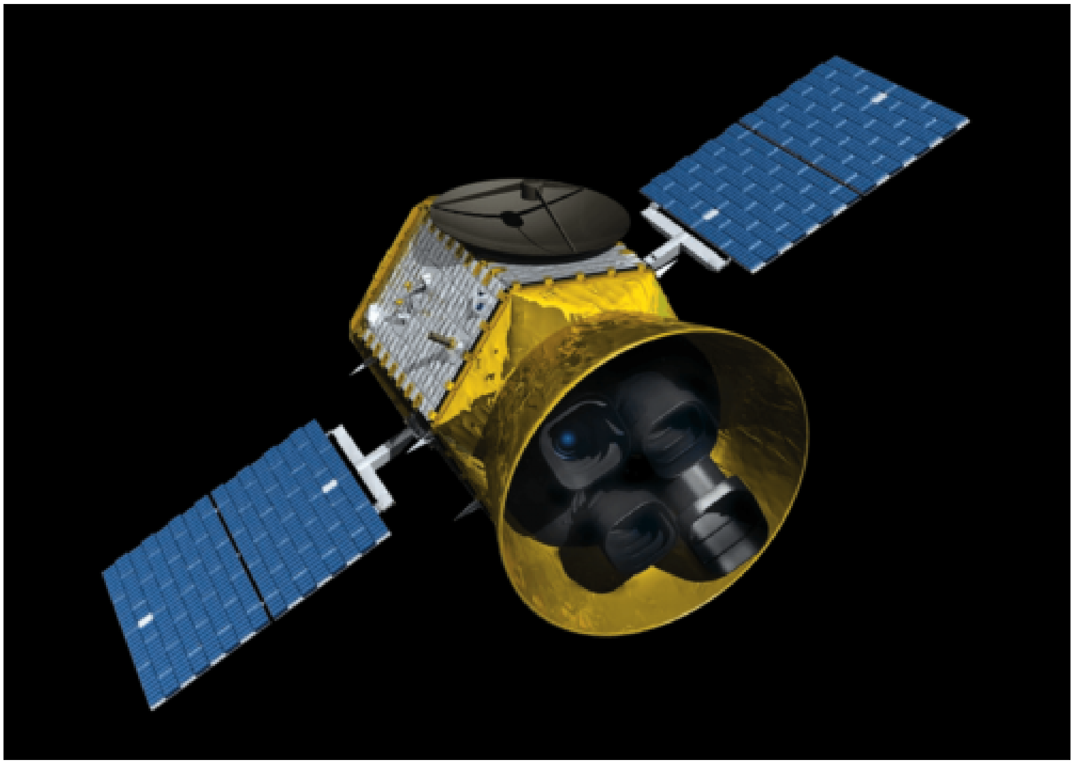
If we find Earth-like planets around nearby stars, spectrographs attached to the GMT will be able to "sniff" their atmospheres, telling us whether they contain oxygen or methane, and facilitating the search for life.

Is there anybody (or any thing) out there?

Over the years, debate has raged on whether life is common or rare in the universe.

The "Rare Earth" philosophy points out that science has had great difficulty in replicating and explaining the origins of life, and argues that the very many different factors that have come together to build the Earth we see around us make it highly unlikely that life could develop and thrive elsewhere.

On the other hand, there is the theory that life is likely to be common throughout the universe. Experiments have shown that viable bacteria could be ejected from Earth, as a result of collisions, and transported to the other planets in the solar system.



An artist's impression of TESS. Credit: NASA

So, perhaps, adjacent planets (such as Earth and Mars) could seed one another with life. Some even argue that life could be transferred from one planetary system to another in this manner!

Even if life is not so easily transported, then many argue that the wealth of planets we're finding around distant stars holds the promise that life could thrive elsewhere.

At the moment, both arguments remain somewhat philosophical, and we remain stuck with a sample of just one planet with life – Earth. But within the coming decades we will hopefully be able to test both hypotheses.

If life is common, then we will eventually find life elsewhere. But even if the search is unsuccessful, we will learn a great deal about how planets are born, live and die, and be reminded once again how precious our own "pale blue dot" truly is.

Source: The Conversation