Further steps in finding an Earth-like planet outside the solar system

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29 June 2016

Last month, researchers analyzing data from the Kepler spacecraft announced 1,284 new confirmed exoplanets, bringing the total to 2,373 discovered by this mission. Twenty-one of these confirmed exoplanets are no more than twice the size of Earth and within their parent star's habitable zone. While no truly Earth-like planet has been found, the prospects of doing so are steadily increasing.

The Kepler spacecraft has been in operation since March 2009, nearly twice its planned mission duration of three and a half years. From 2009 to 2013, it observed approximately 100,000 stars more or less constantly, looking for the subtle but periodic dips in each star's brightness that would indicate a planet transiting (passing in front of) the star.

Spacecraft mechanical issues in 2013 led to a shift in the spacecraft's main mission from the ultra-precise measurements needed to find Earth-sized exoplanets to a broader study of stellar objects including supernova explosions and star formation, although the search for exoplanets continued as well.

Planets that are small, of equal or lesser size than the Earth, are the hardest to isolate in Kepler's observations. Signals from a planet passing in front of a star are often mistaken for noise. Conversely, changes in spacecraft operations or on the star itself can mimic a planetary transit. It takes the labor of hundreds of scientists over years to find and verify the detection of such distant and comparatively tiny objects.

The problem is exacerbated the further away the planet is from its parent star. A planet like Earth orbiting a star like the Sun typically takes about an Earth year to complete its orbit. Since it generally requires three or four orbits to confirm an exoplanet, it takes at least three or four years worth of continuous data to find an Earth-like planet orbiting a Sun-like star.

Despite these difficulties, Kepler and the other exoplanet searches have discovered a total 3,422 exoplanets in 2,560 planetary systems, of which 582 are confirmed multiple-planet systems. Many thousands more await confirmation.

The number and type of exoplanets suggest that they are much more common than previously thought. Even up to 1995, when the first planet orbiting an ordinary star was found outside our Solar System, it was unclear how many stars would have planets around them. We had little more than our own Solar System to base planetary formation models on and had no indication that having such a large planetary family was the normal state of affairs. However, based on Kepler mission data, it is now believed that nearly every star system has at least one planet, whether it be a rocky world like Earth, a gas giant like Jupiter, or any of the myriad types of planets found in between.

In 2013, a team of astronomers took this idea and used the Kepler data to extropolate how many Earth-sized planets there are in the Milky Way galaxy. According to those estimates, there are upwards of *11 billion* Earth-sized planets orbiting Sun-like stars in the Milky Way. Based on the statistics, the closest of these is likely within 12 light years, out of reach for travel based on current technology but a stone's throw on the scale of the galaxy.

Of course, none of these results tell us much about whether or not these planets are *Earth-like.* While some of the larger exoplanets (those larger than Jupiter) have had their atmospheres imaged, it is doubtful that this is possible for Earth-sized planets with the technology that is currently available. It would take a specialized mission to do so.

Such missions have been proposed but none have succeeded in getting the necessary funding. The European Space Agency proposed the Darwin mission, which would use three-space based telescopes aimed at systems with known Earth-sized planets to cancel out the light of the stars and directly image the planets' atmospheres. This would allow us to get the composition of the atmospheres and further narrow down which planets could support Earth-like life. A similar mission by NASA, the Space Interferometry Mission, was proposed by NASA in 1998 and cancelled in 2010 after a series of budget cuts by the Bush and Obama administrations.

This has not, however, stopped efforts to model exoplanetary atmospheres. Astronomers from NASA, UCLA and the University of Washington recently demonstrated that a number of possible atmospheres for the planet Kepler-62f, discovered in 2013, could sustain liquid water on the surface of the planet. This involved varying levels of carbon dioxide and water vapor, as well as testing different configurations for the planet's orbit.

Of course, while studies like these are interesting, they ultimately must be borne out by data. There is no actual observation of Kepler-62f's atmosphere, its surface gravity, surface topology or its magnetic field strength, all of which are essential to understanding whether or not the planet is "habitable."

In our own Solar System, there are only four rocky bodies with atmospheres that have the potential for the development of life—Earth, Mars, Saturn's moon Titan and Neptune's moon Triton. Only Earth currently supports liquid water at its surface. This small sample size does not really allow for a good comparison between models and reality.

This is not a limitation of technology, but of funding. Plans for space telescopes to directly observe the atmospheres of exoplanets have existed since 1988 but none has been given the necessary resources.

No doubt the atmospheres of exoplanets will be as surprising and varied as the exoplanets themselves. The only atmospheres that have so far been detected have been the extremely hot atmospheres of exoplanets orbiting very close to their parent star. Given how many exoplanets there are, at least some will harbor conditions similar to Earth. But as of now, we can only speculate.