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How to Find Other "Earths"

A new laser technique could locate planets much like our own.

By Katherine Bourzac

Astronomers are keen to find a rocky, Earth-like planet revolving around a Sun-like star; it's the most likely place to find life as we know it. But the technologies used to find such planets, which work by analyzing starlight, haven't been up to the task. Now researchers at the Harvard-Smithsonian Center for Astrophysics (http://cfa-www.harvard.edu/) have adapted a relatively young laser technology to discern the once undetectably faint gravitational influence such planets exert on their home stars' light output.

Their system increases the precision of spectrographs--optics used to analyze light from distant stars--by a hundred times, and it should make it possible to detect Earth-like planets. This May, Harvard senior lecturer Ronald Walsworth (http://cfa-www.harvard.edu/Walsworth/Group/Ron/Ron.html) and postdoc Chih-Hao Li (http://cfa-www.harvard.edu/Walsworth/Group/ChihHao.html) will be installing the system at the Multiple Mirror Telescope (http://www.mmto.org/) on Mount Hopkins, in Arizona.

If the Harvard technique holds up in use on actual telescopes, it could be "a huge breakthrough" in the search for Earth-like planets, which will help scientists "understand how our own Earth came to be" and search for life beyond our planet, says Sara Seager (http://eapsweb.mit.edu/people/person.asp?position=Faculty&who=seagers) , a professor of earth and planetary sciences at MIT.

To date, astronomers have discovered nearly 300 planets, called exoplanets, outside our own solar system. For example, just last month, astronomers at NASA announced that the Hubble Space Telescope (http://www.technologyreview.com/BizTech/wtr_11539,295,p1.html) had detected evidence of water and an organic molecule on a planet 63 light years away. But that planet is gaseous and searingly hot; indeed, none of the exoplanets yet found are Earth-like.

As a planet orbits around its star, its gravitational pull "causes the star to wiggle back and forth," says George Ricker (http://space.mit.edu/ACIS/grr.html) , a planetary scientist at MIT. Due to the Doppler effect, this tiny change in the star's motion causes tiny changes in the wavelengths of the starlight that reaches us. Astronomers use an optical tool called a spectrograph to split starlight gathered by telescopes into its component wavelengths. The spectrum of light from a star varies with the period of any orbiting planets, shifting the spectrograph to the blue end and then the red.

The bigger the planet, the easier it is to measure these effects. Large planets, called hot Jupiters because of their resemblance to the one in our solar system, can affect the motion of their stars by tens of centimeters per second. But the effects of small planets like Earth on the motions of their stars are much more subtle, on the order of a centimeter per second, and the shifts in wavelength are correspondingly tiny. "Current techniques have reached a wall at one meter per second," says Gordon Walker (http://www.astro.ubc.ca/people/walker/) , an emeritus professor of physics and astronomy at the University of British Columbia.

In order to determine the wavelengths of light produced by a star, its spectrograph is compared with a standard light source that provides precisely known wavelengths that are stable over time. Exoplanet measurements take place over periods of months or even decades--astronomers light years away would need to watch our Sun for a year to see the effects of Earth. The current standards are stable but limited in the wavelengths they provide.

Since the late 1980s, astronomers have been interested in using optical-frequency combs, spectra of light made by rapidly pulsing lasers, to provide better standards for high-resolution spectroscopy, says John Hall (http://www.colorado.edu/news/nobel/hall/) , a fellow at JILA, a joint research institute of the National Institute of Standards and Technology and the University of Colorado, in Boulder, CO. (Hall won the Nobel Prize in physics in 2005, in part for his work on optical-frequency combs.) Such a spectrum is made by a single laser that produces pulses of light of precisely calibrated wavelengths, spaced billionths of a second apart.

But until now, no one has been able to figure out how to adapt this technology for astronomy: the fringes of light in an unmodified optical-frequency comb are too closely spaced together. To solve this problem, Walsworth and Li coupled an optical-frequency comb with a filtering chamber called a Fabry-Pérot cavity that uses a series of mirrors to cancel out most of the fringes. The resulting fringes act like a ruler for precisely identifying the wavelengths of light in a spectrograph.

"There are a bunch of people working on this, and they beat them out," Seager says of the Harvard researchers. Other groups working on the problem are starting from the top down, designing techniques that need to be combined with better telescopes and better spectrographs also currently under development. Walsworth took a simple approach to the problem. His calibration technique can be used on existing telescopes, with existing spectrographs.

Walsworth says that it will still be a few years before new Earth-like planets are detected using this technique. His group is currently adapting the frequency-comb system for transport from Massachusetts to Arizona, where it will be used to calibrate the spectrograph at the Multiple Mirror Telescope. In 2010, the system will be installed on a state-of-the-art spectrograph in the Canary Islands. "The ultimate goal is to find planets of Earth mass with a one-year period around a Sun-like star," says Walsworth. But he notes that the first discoveries using the new system will be rocky planets orbiting more closely to dimmer, cooler stars.
