Adventures in the 'Goldilocks zone'

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Last Friday's 'picture perfect' launch of the Kepler telescope was the first step in a four-year mission to discover the existence of Earth-like planets elsewhere in our galaxy. (NASA photo)

When NASA's Kepler telescope rocketed into the night sky last week, two Berkeley astronomers watching its fading contrail were hoping that the telescope will reveal Earth's — and humanity's — place in the universe.

Kepler's main goal is to discover Earth-size planets outside our solar

system with conditions conducive to life, but it also will tell us how common rocky planets like Earth are in our Milky Way Galaxy. Of the 300-plus extrasolar planets discovered to date, fewer than a handful are thought to be rocky like the Earth, and none are Earth-size. The rest are gas giants like Jupiter or ice giants like Neptune.

"In part, learning about other Earths — the frequency of them, the environment on them, the stability of the environment on other Earths, their habitability over the eons —is going to teach us about our own Earth, how fragile and special it might be," says astronomy professor Geoff Marcy, a Kepler scientific advisor who, with Paul Butler and a large international planet-hunting team, has discovered nearly half of all known planets outside our solar system. "We learn a little bit about home, ironically, by studying the stars."

Mission co-investigator Gibor Basri, also a Berkeley professor of astronomy, gave the mission a thumbs-up even before Marcy and others discovered the first extrasolar planet in 1995. Back then, Bill Borucki of NASA Ames Research Center in Mountain View, now principal investigator for the Kepler mission, was known for nagging astronomers to search for planets by looking for a slight decrease in a star's brightness as a planet crosses in front of the star — a so-called transit.

Basri was asked to be part of a blue-ribbon panel convened to determine whether Borucki should, as Basri put it, "stop tilting at windmills." At the time, Basri says, "most people didn't appreciate why a transit is a good way to find planets," mainly because astronomers weren't sure that planets are common enough to make such a search fruitful.

Marcy, who first started working on a sensitive Doppler technique for finding planets in 1984, recalls that "it was considered lunatic to look for any planets. When I first started looking, people were embarrassed for me. They would look down at their shoes and wonder why I had

abandoned a perfectly good career to look for planets."

But Basri and others judged that Borucki's transit technique might just work — a conclusion bolstered by the steady stream of newly discovered exoplanets that soon began emerging from Marcy's group and a rival group led by Michel Mayor and Didier Queloz in Switzerland. However, while the Doppler technique can't easily detect Earth-size planets orbiting at Earth's distance from a star, the transit technique should. Basri subsequently joined Borucki and a team of astronomers in proposing the Kepler mission to put a space-borne telescope in orbit to search for transiting Earth-like planets. The mission was approved in 2001.

Getting to the blue ball

NASA is emphasizing Kepler's potential to discover new habitable rocky planets. In a media briefing held at NASA headquarters last month, Marcy collaborator and San Francisco State University astronomer Debra Fischer said that "the ultimate goal of NASA, in 15 years or so, it to take an image of a blue ball. Kepler will tell us how to get to that goal."

Nevertheless, Basri said, "the mission is not just about finding Earth analogs. Even planets not in the habitable zone are of interest to us. Detecting inner-terrestrial plan-ets is relatively easy, and that is where most of our astrophysical information — and an answer to the question, How common are terrestrial planets? — will come from."

Marcy expects to be kept busy by data from Kepler, which will focus on a single region of the sky and snap repeated images of 100,000 stars with its 95-megapixel camera, looking for stars with periodic dimming. Once Kepler team members find a candidate and determine that they're not looking at an eclipsing binary star instead, they will hand it off to Marcy

and colleagues, who have reserved the Lick Observatory's three-meter telescope and the W. M. Keck Ob-servatory's 10-meter telescopes to measure the Doppler-shifted starlight caused by the orbiting planet.

Observing from the comforts of a remote operations facility in the basement of Berkeley's Campbell Hall, Marcy and his colleagues should be able to determine a candidate's mass and orbit and rule out alternatives to an Earth-size planet.

Basri, meanwhile, is standing by in case questions arise about whether stellar dimming is the result of the star's inherent variability rather than a planet transit. An expert on star formation and active stars, he discovered the first young brown dwarf — a hot but failed star — in 1995. Working with Berkeley postdoc Lucianne Walkowicz, Basri will be trying to determine the rotation periods and activity levels of as many Kepler target stars as possible.

Borucki expects to find Earth-size planets within a year of launch, though these would be planets that orbit close to their star and loop around it in weeks to months. For these to be within the star's habitable "Goldilocks zone," where the temperature is "not too hot, not too cold, but just right" to allow water to exist in liquid form, Borucki says, they would have to be orbiting smaller cooler stars such as the reddish M or K dwarfs.

By the end of the three-and-a-half-year mission, Borucki expects to find hundreds of Earth-size planets, including as many as 45 within the habitable zone of their star. Perhaps a few of these will be Earth-size rocky planets orbiting in an Earth-like orbit around a yellow G-type star like our sun — an Earth twin.

"Kepler will not find ET, but we are hoping to find ET's home," Borucki said during the February media briefing. "If we do find dozens of Earth-

like planets in habitable zones, life may be common throughout the galaxy."

Marcy has no doubts. "We are not the only ones; the question is really, How far away are the nearest intelligent beings? That could be a hundred light years or a million light years; we still don't know the answer to that. So Kepler is on the road, a long, long, long yellow brick road toward the Oz of habitable planets and life in the universe."

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