

Rogue Earth-mass planet discovered freely floating in the Milky Way without a star

October 2 2020, by Evan Gough



An artist's illustration of a rogue planet, dark and mysterious. Credit: NASA

If a solar system is a family, then some planets leave home early whether they want to or not. Once they've left the gravitational embrace of their family, they're pretty much destined to drift through interstellar space forever, unbound to any star.

Astronomers like to call these drifters "rogue planets," and they're

getting better at finding them. A team of astronomers have found one of these drifting rogues that's about the same mass as Mars or Earth.

Finding something in deep space that emits no light of its own is extremely challenging. But two organizations are doing just that. They're the Optical Gravitational Lensing Experiment (OGLE) collaboration and the Korean Microlensing Telescope Network (KMTN) collaboration.

Now, a team of scientists from both groups has announced the discovery of a low-mass rogue planet. There are no [stars](#) near it, and its distance from Earth is unconfirmed. The team says it proves that the microlensing technique is effective at finding Earth-mass planets that are free-floating in space.

The paper presenting this discovery is titled "A terrestrial-mass rogue planet candidate detected in the shortest-timescale microlensing event." There are 30 authors listed as contributors for this work, and the lead author is Przemek Mróz, a postdoctoral scholar in astronomy at Caltech. The paper is available on the pre-press site arxiv.org.

Astronomers think that in the early days of a [solar system](#), some low-mass planets will be ejected from the star's gravitational grip. Things can be chaotic in the early days, and gravitational interactions between the star and all the planets can sometimes send [small planets](#) out into space to fend for themselves. "According to planet-formation theories, such as the core accretion theory, typical masses of ejected planets should be between 0.3 and 1.0 Earth masses," the authors write.

Finding these tiny bodies in the vast darkness of space requires an innovative approach: gravitational lensing.

[Gravitational lensing](#) requires two things: A distant light source, usually a star, and a closer object with enough mass to act as a lens and to bend

the light from the light source. In this case, the low-mass planet acts as the lens. And depending on how much the light from the distant star is affected by the foreground object, astronomers can learn quite a bit.

A relatively tiny object like a low-mass planet doesn't bend much light, and not for too long, either. In their paper, the authors say, "Microlensing events due to terrestrial-mass rogue planets are expected to have extremely small angular Einstein radii ($.1 \mu\text{as}$) and extremely short timescales (0.1 day)." According to the authors, this is the "most extreme short-timescale microlens discovered to date."

In the last couple of decades, knowledge of exoplanets has exploded. We now know of thousands of them, and we expect that almost every star hosts planets. All of this knowledge has led to updated theories and models of planet and solar system formation. And those models show that there should be a lot of rogue planets that were ejected from their systems.



Artist's rendering of an Earth-sized rogue planet approaching a star. Credit: Christine Pulliam (CfA)

Theoretical work shows that there could be billions, or even trillions, of free-floating planets in the Milky Way. In their work, the authors lists the ways these planets can end up orphaned: Planet-planet scattering; dynamical interactions between [giant planets](#) that lead to orbital disruption of smaller, inner planets; interactions between the stars in binary or trinary systems and star clusters; stellar fly-bys; and the evolution of the host star past the [main sequence](#).

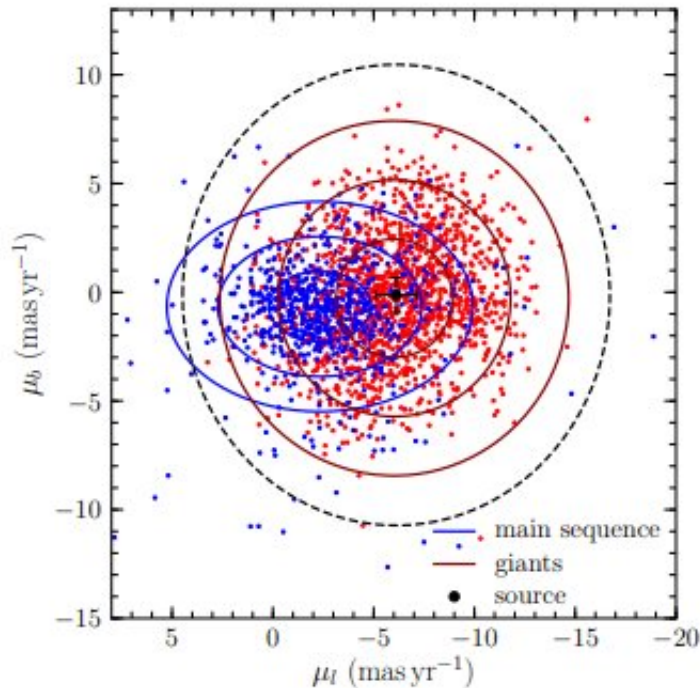
Microlensing offers a method of finding these small rogue planets. But

it's difficult. It's not their dimness that's the problem. It's that the microlensing events for bodies this small are on a very short timescale due to their size. The newly discovered planet, which has been named "OGLE-2016-BLG-1928," was discovered in a microlensing event that lasted only 41.5 minutes. That's not much time for detailed data to be gathered.

Only four other small rogue planets like this one have been found before, each one in a short timescale micro-lensing event. Together, these events provide "strong evidence for a population of rogue planets in the Milky Way," the authors write.

The researchers faced a host of difficulties in not only detecting this event, but in determining that it was, indeed, a planet.

"As in the case of other short timescale microlensing events, we cannot rule out the presence of a distant stellar companion," they write. They were able to exclude any stellar companions out to a distance of only 8 AUs. But many planets orbit their stars at much greater distances than that.



This figure from the study shows the star that acted as the light source in the micro-lensing event. Red dots mark red giant stars in the galactic bulge, and blue dots represent main sequence stars in the galactic disk. Gaia data indicates that the source star is a red giant in the galactic bulge. Credit: Mroz et al, 2020

This planet was also found "...at the edge of current limits of detecting short-timescale microlensing events," the paper says. The authors say this points out the difficulty of searches for such events. The event was detected with relatively few data points, too: only 15. (11 were from OGLE and four were from KMTN.)

The small number of [data points](#) in the detection means that the "declining part of the light curve is not fully covered with observations." That data shortfall means there's some uncertainty around the nature of the microlensing event, and some uncertainty around it actually being a planet. Part of that uncertainty stems from the background star itself.

"The source star is located in the red giant branch in the color–magnitude diagram, and some giants are known to produce stellar flares," the authors write. Could they conclusively rule out stellar flares as the cause of the event, rather than a rogue planet? "... the properties of the event (its duration, amplitude, and light curve shape) do not match those of flaring stars." they conclude.

But even with the uncertainties, this discovery is still important. "Thus, the lens is one of the best candidates for a terrestrial-mass rogue planet detected to date," they write. Even though their mass measurement for the object is somewhat ambivalent, the other properties of the event are "...consistent with the lens being a sub Earth-mass object with no stellar companion up to the projected distance of about 8 au from the planet."

Rogue planets have almost zero potential for hosting life, so they may not become a significant field of study like the search for exoplanets. But they're still intriguing, and like everything else, they hold clues to how nature works.

In the future, the Nancy Grace Roman Space Telescope will aid in the search for rogue planets. It has a lot on its plate for its mission, including some huge issues like dark energy, and some eagerly awaited tasks like imaging exoplanets and obtaining spectra of their atmospheres.

But part of its job is also to [find free-floating rogue planets](#) as small as Mars. The ultra-powerful space telescope will conduct a large microlensing survey to find more of these planets. Its findings will help us understand better how our own solar system stacks up to others.

"As our view of the universe has expanded, we've realized that our solar system may be unusual," said Samson Johnson, a graduate student at Ohio State University in Columbus, in a press release. "Roman will help us learn more about how we fit in the cosmic scheme of things by

studying rogue [planets](#)."

More information: Mroz et al., A terrestrial-mass rogue planet candidate detected in the shortest-timescale microlensing event. arXiv:2009.12377 [astro-ph.EP]. arxiv.org/abs/2009.12377

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