How to Find Another Earth

A "starshade" flying in front of NASA's upcoming big telescope could deliver images of potentially habitable worlds decades ahead of schedule.

Can a next-generation NASA space telescope take pictures of other Earth-like planets? Astronomers have long dreamed of such pictures, which would allow them to study worlds beyond our solar system for signs of habitability and life. But for as long as astronomers have dreamed, the technology to make it happen has seemed many decades away. Now, however, a growing number of experts think NASA's Wide-Field Infrared Survey Telescope (WFIRST) could take snapshots of other "Earths"—and soon. The agency formally started work on the observatory in February of this year and plans to launch it in 2025.

When WFIRST launches, it will sport a 2.4-meter mirror that promises panoramic views of the heavens and will use its wide eye to study dark energy, the mysterious force driving the universe's accelerating expansion. But another hot topic—the existential quest to know whether we are alone in the universe—is already influencing the mission. Researchers have discovered more than 3,000 planets around other stars and expect to find tens of thousands more within the next decade. Rough statistics suggest that...
every star in the sky is accompanied by at least one such exoplanet and that perhaps one in five sunlike stars bears a rocky orb in a not too hot, not too cold "habitable zone" where liquid water can exist. The best way to learn whether any of these worlds are Earth-like is to see them, but taking a planet's picture from light-years away is far from easy. A habitable world would be a faint dot lost in the overpowering glare of its larger, 10 billion times brighter star.

Earth's turbulent, starlight-blurring atmosphere is also a severe obstacle to imaging faint planets from ground-based observatories, and most experts agree that the solution is to use space telescopes. But neither NASA's Hubble Space Telescope nor its supersize successor, the James Webb Space Telescope set for launch in 2018, comes close to the high contrast needed. To help capture planetary shots, WFIRST will have an advanced planet-imaging coronagraph, an instrument inside the telescope that filters out starlight using a complex series of masks, mirrors and lenses. But this instrument was a late addition to WFIRST, which is not optimized for a coronagraph. Consequently, most experts predict that its coronagraph will fall short of the contrast required to image other Earths. Indeed, snapping such images is so challenging that NASA's tentative plans call for putting it off for perhaps 20 years or more as the agency develops the technology and budgetary breathing room to build an entirely new space telescope after WFIRST.

A device called a starshade might offer a shortcut. A starshade is a sunflower-shaped, paper-thin screen half as big as a football field that would float tens of thousands of kilometers directly ahead of WFIRST, blocking out a target star's light in much the same way one might blot out the sun in the sky with an extended thumb. Because starshades work with practically any telescope, one on WFIRST could cast a deeper shadow and see fainter planets than a coronagraph. Working in tandem, the starshade and the telescope could take pictures of perhaps 40 planets, including a few that in size and orbit would mirror Earth. "If and only if it had a starshade, WFIRST could give us images of a few true-blue Earths late next decade rather than waiting for another 20 years," says Jeremy Kasdin, a Princeton University professor and lead scientist for WFIRST's coronagraph. "This is a real opportunity to find another Earth sooner and for less money before making a huge investment in NASA's next giant space telescope."

Despite WFIRST being nearly a decade away from launch, the decision to move forward with preparations for a starshade rendezvous must come soon because WFIRST must receive minor modifications to allow it to sync up with a starshade across tens of thousands of kilometers of empty space. As such, an official starshade mission does not exist. Instead Paul Hertz, director of NASA's astrophysics division, says the agency is "in a 'don't preclude a starshade' mode." So far not precluding a starshade closely resembles a concerted effort to build one: when NASA first announced the formal start of WFIRST, it also confirmed that the telescope would be launched into an orbit 1.5 million kilometers from Earth, where conditions are tranquil enough for a starshade to function. In addition, the agency recently formed the StarShade Readiness Working Group and officially designated the starshade as a "technology development activity"—moves that could accelerate the agency's progress.

In fact, in the basement of Princeton's sprawling Frick Chemistry Laboratory, Kasdin is already working on a test bed:

MODEL ORGANISMS

Lab Mice Are Too Clean

Housing lab-grown mice with "dirty" rodents from pet stores makes for better human models

Scientists usually order laboratory mice online, but immunologist David Masopust went to more trouble. While doing research years ago at Emory University, he drove to a barn several hours away to trap the rodents himself. He suspected that commercially provided lab mice were missing some key immune cells because they had inexperienced immune systems—a result of being raised in extremely hygienic facilities. Masopust, now a professor at the University of Minnesota, went on to formally test his suspicion over the course of a decade and has found that it was correct: lab mice used by the scientific community and pharmaceutical world to test drugs and vaccines for human diseases are in some ways poor models of the human adult immune system.

As published this spring in the journal Nature, Masopust and his colleagues discovered that mice raised in germ-free facilities had immune systems that looked more like those of human babies than adults, as judged by the types of immune cells present and the genes that were active in those cells. For example, memory CD8+ T cells that serve as first responders to infection were virtually undetectable in adult lab mice but clearly present in barn mice and mice from pet stores. "We've known this, but it's good to finally see it proven," says Purvesh Khatri, a computational systems immunologist at Stanford University who was not involved in the study.

What is more, when the researchers housed "clean" lab mice with "dirty" pet store mice (which carried germs), about a fifth of the lab mice died of infections within a few months. The mice that survived, however, developed more robust immune repertoires, and the gene activity of their immune cells shifted to resemble those of adult humans. In follow-up experiments, those mice fought off