New astronomical instrument on the hunt for exoplanets

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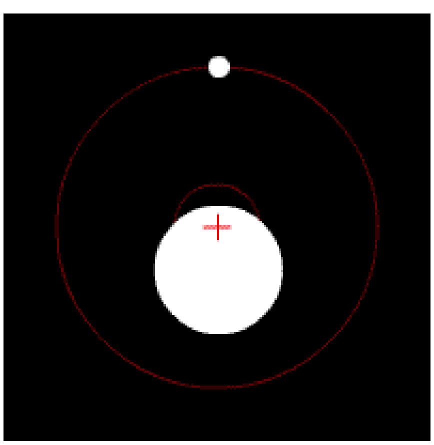
Credit: University of Pennsylvania

At the highest point of the Quinlan mountains, overlooking the Sonoran Desert as it stretches across southern Arizona, NEID (pronounced like "fluid") recently collected its first observations, known colloquially by astronomers as "first light," at the Kitt Peak National Observatory.

Installed at the 3.5 meter Wisconsin-Indiana-Yale-NOAO (WIYN) Telescope, NEID can measure changes in the motion of nearby stars with high precision. This state-of-the-art instrument, which takes its name from the Tohono O'odham word meaning "to see," is now on the hunt for exoplanets, ones that orbit stars outside the solar system, and will be able to detect, measure, and characterize new planets more accurately than ever before.

One way that astronomers can find new exoplanets is by using the "wobble" method. Two objects in orbit, like the Earth and sun, move around a common center of mass. Astronomers can look for this periodic shift in a star's velocity as it moves as a way of figuring out if the star has any planets orbiting around it.

The primary challenge with building NEID, which has several times more precision than any existing instrument of its class, involved refining and optimizing its numerous components. To do this, astronomer Cullen Blake partnered with researchers at Penn State and submitted a proposal to NASA and the National Science Foundation to design and build NEID.



As a planet (smaller circle) orbits a star (larger circle), the star itself will also move in a small orbit around the combined system's center of mass (red plus sign). Credit: University of Pennsylvania

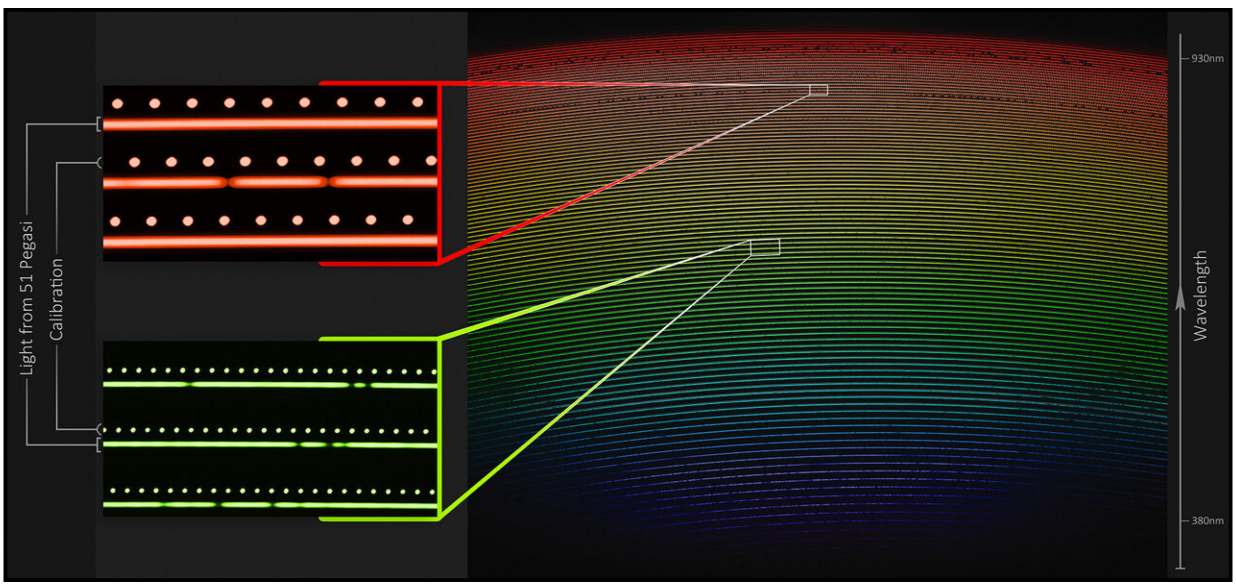
Temperature control on an aggressive timeline

As one of NEID's instrument scientists, Blake says that one of the big tests they faced was in creating an instrument with very fine levels of temperature control. The optical devices inside NEID, a large metal vessel about the size of a car, need to be kept at a constant temperature of 300 Kelvin (around 80 F or 26 C) and stable to within one thousandth of a degree. "If the temperature inside the instrument changes, it will masquerade like the signal you are looking for," explains Blake. "You have to really control that."

After obtaining the largest commercially available Charge Coupled Device, the digital detector that records a distant star's light, Penn researchers in Blake's lab, including former post-docs Dan Li and Sam Halverson and Ph.D. student Mark Giovinazzi, designed and built the mount that houses the detector in order to have optimal temperature control. After assembling the device and mount using clean room facilities at the Singh Center's Quattrone Nanofabrication Facility, the researchers conducted a year's worth of tests to make sure the detector was performing up to specifications before taking it to State College and assembling the detector into NEID. It was then taken to the Kitt Observatory for installation.

NEID's first-light observations targeted the star 51 Pegasi, the first sun-like star which in 1995 was found to host an exoplanet. This marks an important first milestone for the instrument and is "the first verification that NEID is measuring starlight as expected and is on its way to full functionality," says Jason Wright, NEID project scientist at Penn State University.

From initial design to installation, NEID was finished in four years, a short amount of time to integrate the many different components in what is typically a decade-long endeavor. The reason for the aggressive schedule was NASA's Transitioning Exoplanet Survey Satellite (TESS), a space-based mission that's also on the hunt for exoplanets. TESS recently released new lists of candidate exoplanets that are observable from the Northern Hemisphere, which researchers can now take advantage of and study further using NEID.



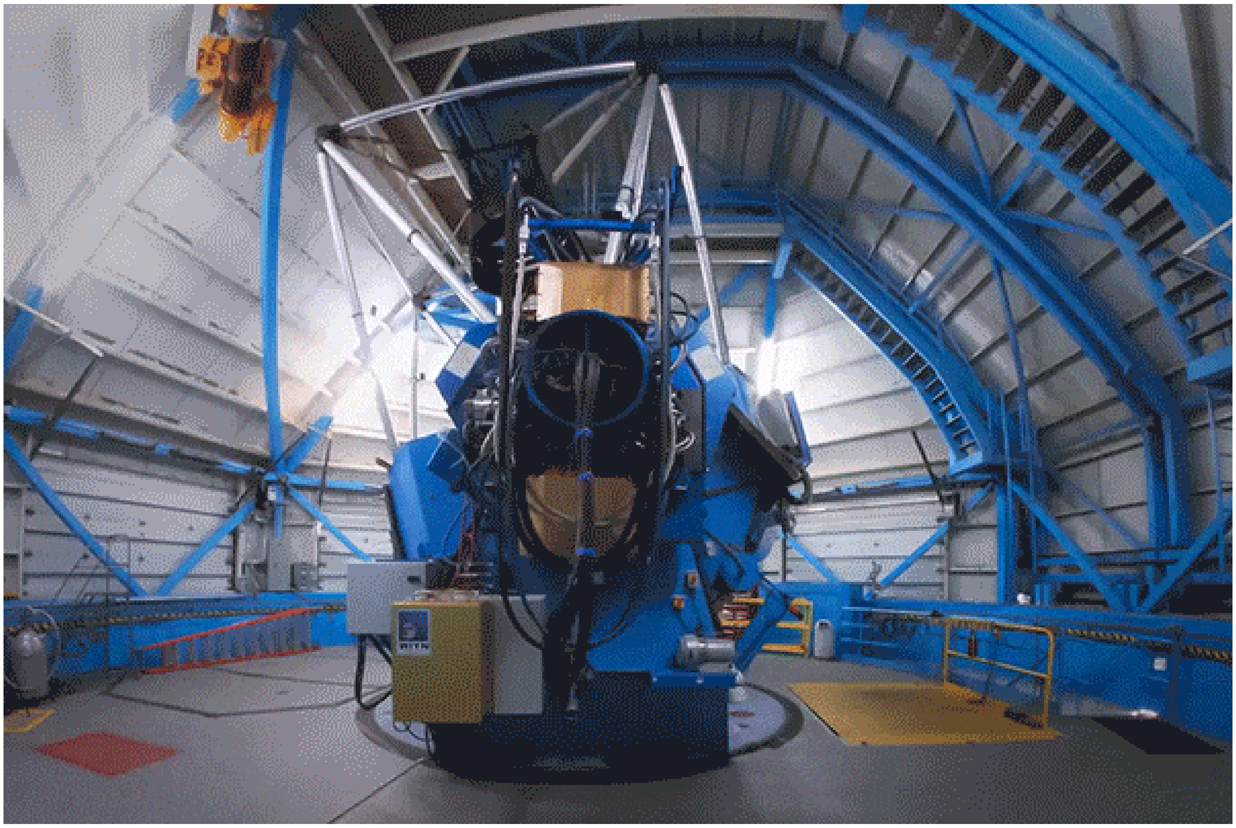
First light image of the 51 Pegasi spectrum captured by NEID. The left panel shows the light spectrum from the star from short (blue) to long (red) wavelengths. Light deficits, shown as dark interruptions along the spectrum (zoomed in panel on the right) show the "fingerprints" of elements present in the star's atmosphere. By measuring the subtle motion of these features, astronomers can detect a star's "wobble" in response to an orbiting planet. Credit: Guðmundur Kári Stefánsson/Princeton University/NSF's National Optical-Infrared Astronomy Research Laboratory/KPNO/NSF/AURA

Exoplanets on the horizon

The astronomy community was excited to first learn about NEID's first light at the 235th American Astronomical Society meeting last week. While the instrument technicians and operators are still working out NEID's kinks, Blake says that they are making regular observations and is confident that NEID will be fully operational within the next couple of months. Blake also adds that having full-time staff on site will mean less time required by researchers for making observations and instrument troubleshooting. "That will be one of the things that really helps increase the science impact—having professional observers there all the time who are getting the best science they can get," says Blake.

As a new instrument that's "a decade ahead of what the U.S. community had access to before," Blake hopes that NEID will find a long-term home at Kitt Peak, where it will be available to the entire U.S. astronomy community. Much of the Observatory's time in the near future will be dedicated to the hunt for exoplanets, which Blake says can greatly increase the chances of both finding new planets and conducting detailed and effective scientific studies about them.

"One thing we've come to learn is that you can build the fanciest instrument you want, but one thing that is invaluable is having as many nights on the telescope as you can," says Blake. "The stars themselves do all sorts of things that complicate this measurement we're trying to make, and one way to attack that is to have as many observations close in time as possible."



he WIYN mirror and telescopes structure in action. Credit: NSF's National Optical-Infrared Astronomy Research Laboratory/KPNO/NSF/AURA

Because of its state-of-the-art capabilities, NEID will excel at finding Earth-sized planets within a star's habitable zone—not too close to the star to be too hot, and not too far from the sun to be too cold—and will be extremely good at finding new planets that orbit around much smaller stars. And with the recent announcement of the first earth-sized planet found within a star's habitable zone, and more exoplanet findings likely as TESS continues to study the skies, NEID will play an active role in following up on such findings in the future.

With all the myriad capabilities that NEID brings to the field, it will certainly keep Blake and other astronomers busy on the exoplanet hunt in the coming years. "I'm looking forward to getting large sets of production-quality data, studying planetary systems that are interesting, and getting down into the weeds on what we can tease out of the data, to see how low can we go in terms of planet masses that would be detectable," says Blake. "It's exciting to go from the building and hardware phase to doing science. It will be neat to see what we learn."

Provided by University of Pennsylvania