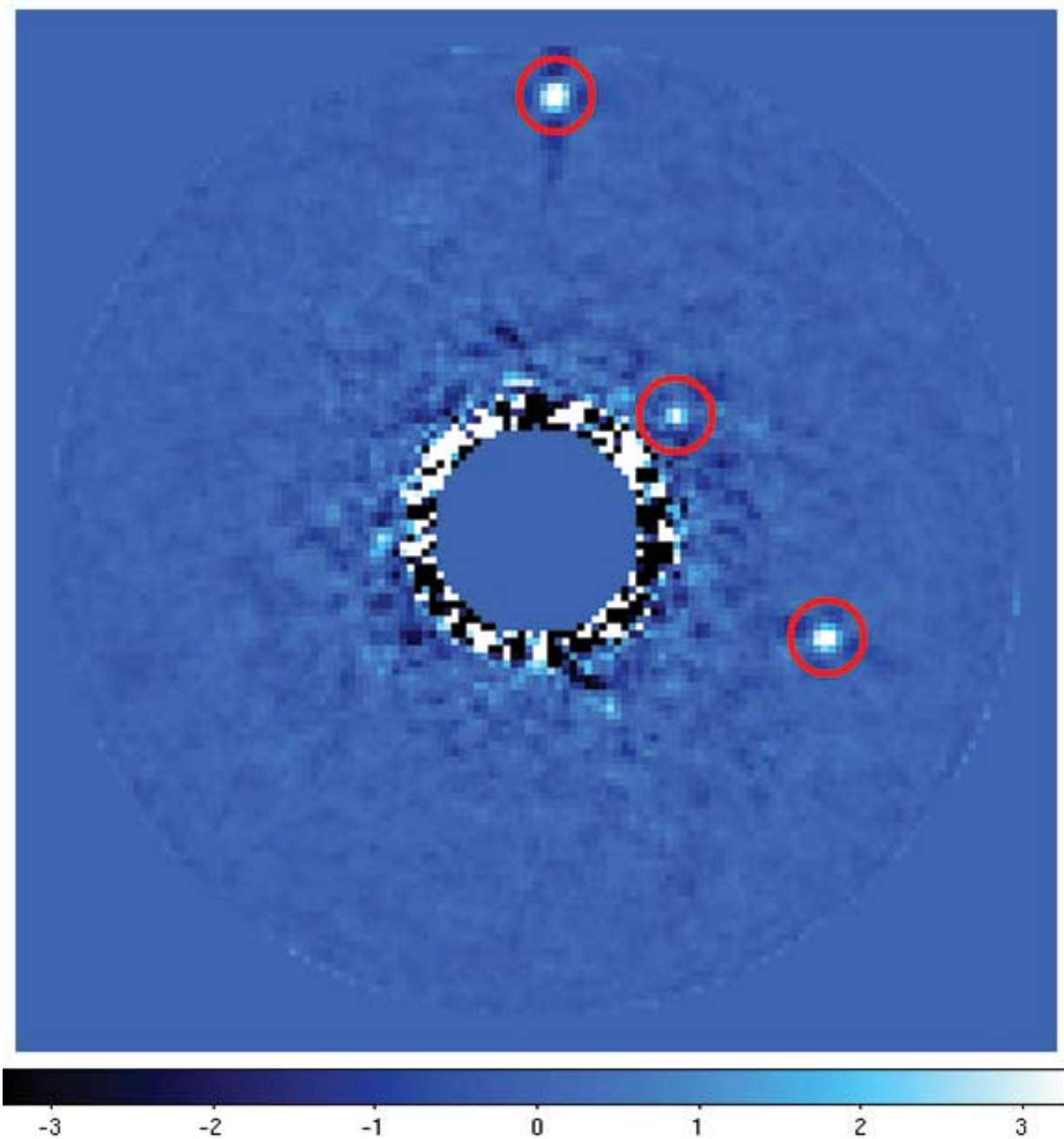


# Earth-bound instrument analyzes light from planets circling distant stars

November 10 2016, by John Sullivan

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Researchers led by Princeton scientists successfully operated a new instrument, the CHARIS spectrograph, which allows them to make detailed observations of planets orbiting distant stars. Above, a plot of data from CHARIS shows planets located around a star in the planetary system HR8799. Credit: N. Jeremy Kasdin and the research team

A team of scientists and engineers led by Princeton researchers recently reported the successful operation of a new instrument for the Subaru Telescope in Hawaii that will allow astronomers to make direct observations of planets orbiting nearby stars.

The instrument, dubbed CHARIS, was designed and built by a team led by N. Jeremy Kasdin, a professor of mechanical and aerospace engineering. It allows astronomers to isolate light reflecting from [planets](#) larger than Jupiter and then analyze the light to determine details about the planets' size, age and atmospheric constituents. The recent observation is known in the astronomical community as a "first light," a first field test of the instrument on the telescope that demonstrates it is operating successfully.

"We couldn't have been more pleased by the results," said Kasdin. "CHARIS exceeded all of our expectations. I can't praise our team enough for their extremely hard work and dedication that made CHARIS a success. It is on track to be available for science observations starting in February 2017."

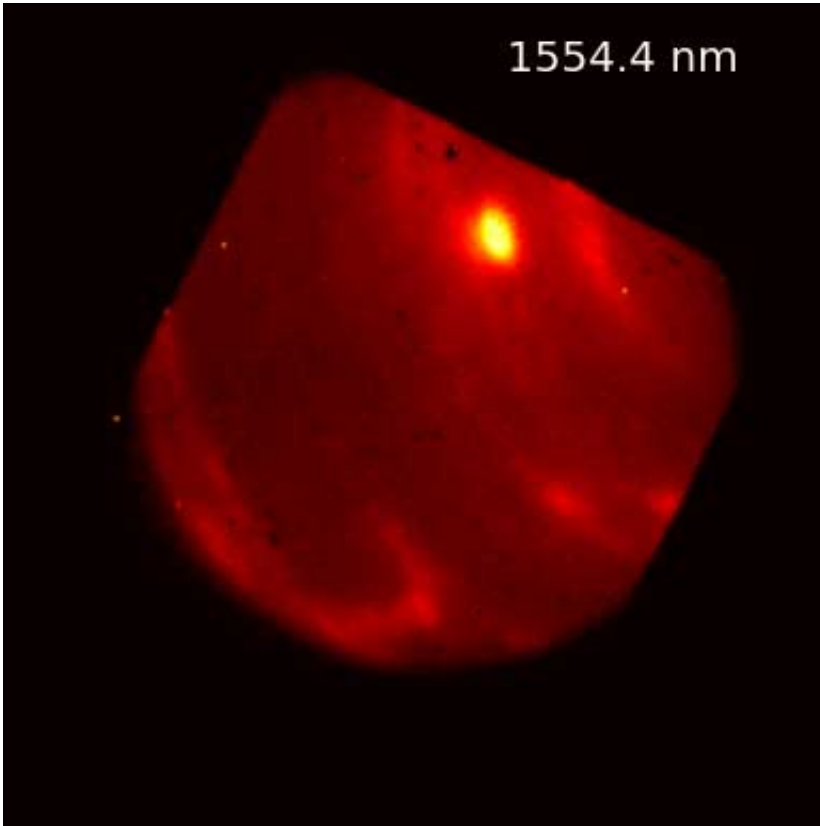
CHARIS, an acronym for the Coronagraphic High Angular Resolution Imaging Spectrograph, is part of a major effort in astronomy to find and analyze planets orbiting distant stars, known as exoplanets. Since the first

discovery of an exoplanet in 1995, researchers have discovered over 1,000 such planets, a large majority coming from NASA's Kepler space observatory. Nearly all of those discoveries relied on using minute changes in stellar light to identify the presence of planets; as a result, those observations cannot tell scientists much about the planets themselves.

More recent projects have demonstrated the ability to capture light reflected from a planet and separate it from the light shining directly from its parent star. Those efforts allow scientists to examine the light and determine the chemical makeup of the planet's atmosphere in the same way that chemists use the spectrum of light (the wavelength or colors of light) to analyze the composition of material in a lab. The CHARIS project is part of that effort. Currently, CHARIS is the only spectrograph dedicated to exoplanet research on an 8-meter class telescope in the Northern Hemisphere.

"CHARIS is a key addition to the growing exoplanet imaging and characterization capabilities at Subaru Telescope," said Olivier Guyon, the leader of the [adaptive optics](#) program at Subaru and a faculty member at the University of Arizona. "With CHARIS spectra we can now do a lot more than simply detect planets: we can measure their temperatures and atmosphere compositions."

The CHARIS project is part of a long-term collaboration among Princeton, the University of Tokyo and the National Astronomical Observatory of Japan, which operates the Subaru Telescope at Mauna Kea, Hawaii. The CHARIS instrument was designed and built at Princeton under the direction of Tyler Groff, a former doctoral student and associate research scholar working with Kasdin, who now works for NASA's Goddard Space Flight Center.



Researchers used the CHARIS spectrograph to take images of celestial objects during a recent successful field test, including vapor clouds moving across a section of the planet Neptune captured in the instrument's view. Credit: N. Jeremy Kasdin and the research team

"By analyzing the spectrum of a planet, we can really understand a lot about the planet," Groff said. "You can see specific features that can allow you to understand the mass, the temperature, the age of the planet."

The spectrograph is sealed in a 500-pound case measuring 30 inches by 30 inches by 12 inches and operates at a temperature of 50 degrees Kelvin (-370 degrees Fahrenheit). The assembly includes nine mirrors, five filters, two prism assemblies and a microlens array—a special optical device with an array of tiny lenses etched into its surface. The

research team took five years to complete CHARIS.

The spectrograph sits behind a device called a coronagraph, which channels light from the telescope and uses interference patterns to divide the light coming directly from a star from the light reflecting off orbiting planets. It is a bit like picking out the light reflecting from a speck of tinsel floating in front a spotlight hundreds of miles away. The researchers said that the high contrast in the image is key to a successful observation. The Subaru Telescope achieves this through a combination of the CHARIS instrument and adaptive optics called the Subaru Coronagraphic Extreme Adaptive Optics. Nemanja Jovanovic, who is part of Guyon's team at Subaru, led efforts to integrate the two systems.

CHARIS has a relatively narrow field of view. Groff said it observes about 2 arcseconds of the sky. (The full moon seen from Earth is about 1,800 arcseconds.) But it has the ability to take images across a very wide band of wavelengths of [light](#), allowing for detailed analysis of anything in its field.

"We tested CHARIS on Neptune, but the entire planet doesn't even fit on our detector," Groff said. However, the spectrograph's field of view is so detailed that the researchers were able to make interesting observations of clouds floating across the planet's surface.

The CHARIS project was the work of a large team of researchers. Kasdin and Masahiko Hayashi, of the National Astronomical Observatory of Japan, are the principal investigators. In addition to Groff, other team members included: Michael Galvin, Michael Carr, Craig Loomis, Norman Jarosik, Johnny Greco, Robert Lupton, Edwin Turner, James Gunn and Gillian Knapp of Princeton; Mary Anne Limbach of Limbach Optics; Nemanja Johanovic, of the Subaru Telescope; Timothy Brandt of the Institute for Advanced Study; and Jeffrey Chilcote of the University of Toronto.

Groff said there has been a great deal of interest in the project in the [astronomical community](#) and the principal investigators are now reviewing research proposals.

"There is a lot of excitement," he said. "CHARIS is going to open for science in February to everyone."

Provided by Princeton University

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