Astronomer's First Direct Evidence: Young Low−Mass Objects are Twice as Heavy as Predicted

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ASTRONOMERS' FIRST DIRECT EVIDENCE: YOUNG LOW−MASS OBJECTS ARE TWICE AS HEAVY AS PREDICTED

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Lori Stiles

Although mass is the most important property of stars, it has proved very hard to measure for the lowest mass objects in the universe. Thanks to a powerful new camera, a very rare, low−mass companion has finally been photographed.

The discovery suggests that, due to errors in the models, astronomers have overestimated the number of young "brown dwarfs" and "free floating" extrasolar planets. An international team of astronomers lead by University of Arizona Associate Professor Laird Close reports the discovery in today's (Jan 20.) issue of Nature.

The image has allowed the team to directly measure the mass of a young, very low mass object for the first time. The object, more than 100 times fainter than its close primary star, is 93 times as massive as Jupiter −− almost twice as heavy as theory predicts it should be. Their findings challenge current ideas about the astronomical brown dwarf population and the existence of widely publicized free−floating extrasolar planets.

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Related Web sites

NACO_SDI camera −
http://exoplanet.as.arizona.edu/~lclose/talks/ins/SDI_NACO.html

Laird Close homepage − http://athene.as.arizona.edu/~lclose/

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Brown dwarfs are objects 75 times more massive than Jupiter but not
massive
enough to burn as stars. If young objects identified as brown dwarfs
are
twice as massive as has been thought, many actually are low mass stars.
Objects recently identified as 'free−floating' planets are in turn
likely
just low mass brown dwarfs.

Close of the UA's Steward Observatory and his international colleagues
detected the faint, very−low−mass companion, named AB Dor C, which
orbits
the very young star AB Doradus A (AB Dor A) at only 2.3 times the
distance
between the Earth and the sun, or about the distance between the sun
and the
asteroids beyond Mars.

Astronomers searching for very low mass objects look at young nearby
stars
because low mass companion objects will be brightest when young, before
they
contract and cool. Astronomers had suspected since the early 1990s that
well−known AB Dor A −− a star 48 light years (14.9 parsecs) from Earth
and
only 50 million years old −− has a low−mass companion because its
position
'wobbles' as it is pulled by an unseen companion. But even the Hubble
Space
Telescope tried and failed to detect the companion because it was too
faint
and too close to the glare of the primary star.

Close and his colleagues from Germany (Rainer Lenzen, Wolfgang
Brandner),
Spain (Jose C. Guirado), Chile (Markus Hartung, Chris Lidman), and the

United States (Eric Nielsen, Eric Mamajek, and Beth Biller) succeeded in photographing the elusive companion. They used Close and Lenzen's novel high−contrast camera on the European Southern Observatory's 8.2−meter Very Large Telescope in Chile in February 2004.

Close and Lenzen developed the new high−contrast adaptive optics camera, the NACO Simultaneous Differential Imager, or NACO SDI, for hunting extrasolar planets. The SDI camera enhances the ability of the powerful 8.2−meter VLT telescope and its existing adaptive optics system to detect faint companions that normally would be lost in the glare of the primary star.

Close and his team are the first to image a companion so faint 120 times fainter than its star −− and so near its star. The tiny distance between the star and the faint companion (0.156 arcseconds) is the same as the width of a dime (1.5 centimeters) seen 8 miles (13 kilometers) away. Once they located the companion, they observed it at near infrared wavelengths to measure its temperature and luminosity.

"We were surprised to find that the companion was 400 degrees Celsius cooler and 2.5 times fainter than the latest models predicted," Close said.

"We used our discovery of the companion's exact location, along with the star's known 'wobble', to accurately determine the companion's mass," team member Jose Guirado said.

"Theory predicts that this low−mass, cool object would be about 50 Jupiter masses," Close said. "But theory is incorrect: This object is between 88−98 Jupiter masses. This discovery will force astronomers to rethink what masses of the smallest objects produced in nature really are."

"Objects like AB Dor C are very rare," Wolfgang Brandner said. "Only one percent of stars have close very low mass companions −− and only about one percent of nearby stars are young. Hence, we are very lucky to be able to

accurately measure the mass of even a single low mass companion that is accurately known to be young."

The NACO SDI camera is a unique type of camera using adaptive optics, which removes the blurring effects of Earth's atmosphere to produce extremely shape images. SDI splits light from a single star into four identical images, then passes the resulting beams through four slightly different methane−sensitive filters. When the filtered light beams hit the camera's detector array, astronomers can subtract the images so the bright star disappears, revealing a fainter, lower−mass methane−rich object otherwise hidden in the star's scattered light halo.

The National Science Foundation awarded Close a prestigious 5−year, $545,000 Faculty Early Career Development award that supports his search for extrasolar planets using SDI cameras on the European Southern Observatory's 8.2−meter VLT in Chile and on the UA/Smithsonian 6.5−meter MMT on Mount Hopkins, Ariz. This research was also supported by NASA.

Authors of the Jan. 20 Nature letter, "A dynamical calibration of the mass−luminosity relation at very low stellar masses and young ages," are:
Laird Close of the UA Steward Observatory, Rainer Lenzen of the Max Planck Institute for Astronomy in Heidelberg, Jose C. Guirado of the University of Valencia (Spain), Eric L. Nielsen of UA Steward Observatory, Eric E. Mamajek of the Harvard−Smithsonian Center for Astrophysics, Wolfgang Brandner of the Max Planck Institute for Astronomy in Heidelberg, Markus Hartung and Chris Lindman of the European Southern Observatory (Chile), and Beth Biller of the UA Steward Observatory.

More information and images are available on the Web sites http://exoplanet.as.arizona.edu/~lclose/talks/ins/SDI_NACO.html and http://athene.as.arizona.edu/~lclose/