Watching an exoplanet in motion around a distant star

September 16 2015

A series of images taken between November 2013 to April 2015 with the Gemini Planet Imager (GPI) on the Gemini South telescope in Chile shows the exoplanet β Pic b orbiting the star β Pictoris, which lies over 60 light-years from Earth. In the images, the star is at the centre of the left-hand edge of the frame; it is hidden by the Gemini Planet Imager's coronagraph. We are looking at the planet's orbit almost edge-on; the planet is closer to the Earth than the star. The images are based on observations described in a paper published in the Astrophysical Journal, 16 September 2015 and whose lead author is Maxwell Millar-Blanchaer. GPI is a groundbreaking instrument that was developed by an international team led by Stanford University's Prof. Bruce Macintosh (a U of T alumnus) and the University of California Berkeley's Prof. James Graham

(former director of the Dunlap Institute for Astronomy & Astrophysics, U of T). Credit: M. Millar-Blanchaer, University of Toronto; R. Marchis (SETI Institute)

A team of astronomers has given us our best view yet of an exoplanet moving in its orbit around a distant star. A series of images captured between November 2013 to April 2015 shows the exoplanet β Pic b as it moves through 1.5 years of its 22-year orbital period.

First discovered in 2008, β Pic b is a gas giant planet ten to twelve times the mass of Jupiter, with an orbit roughly the diameter of Saturn's. It is part of the dynamic and complex system of the star β Pictoris which lies over 60 light-years from Earth. The system includes comets, orbiting gas clouds, and an enormous debris disk that in our Solar System would extend from Neptune's orbit to nearly two thousand times the Sun/Earth distance.

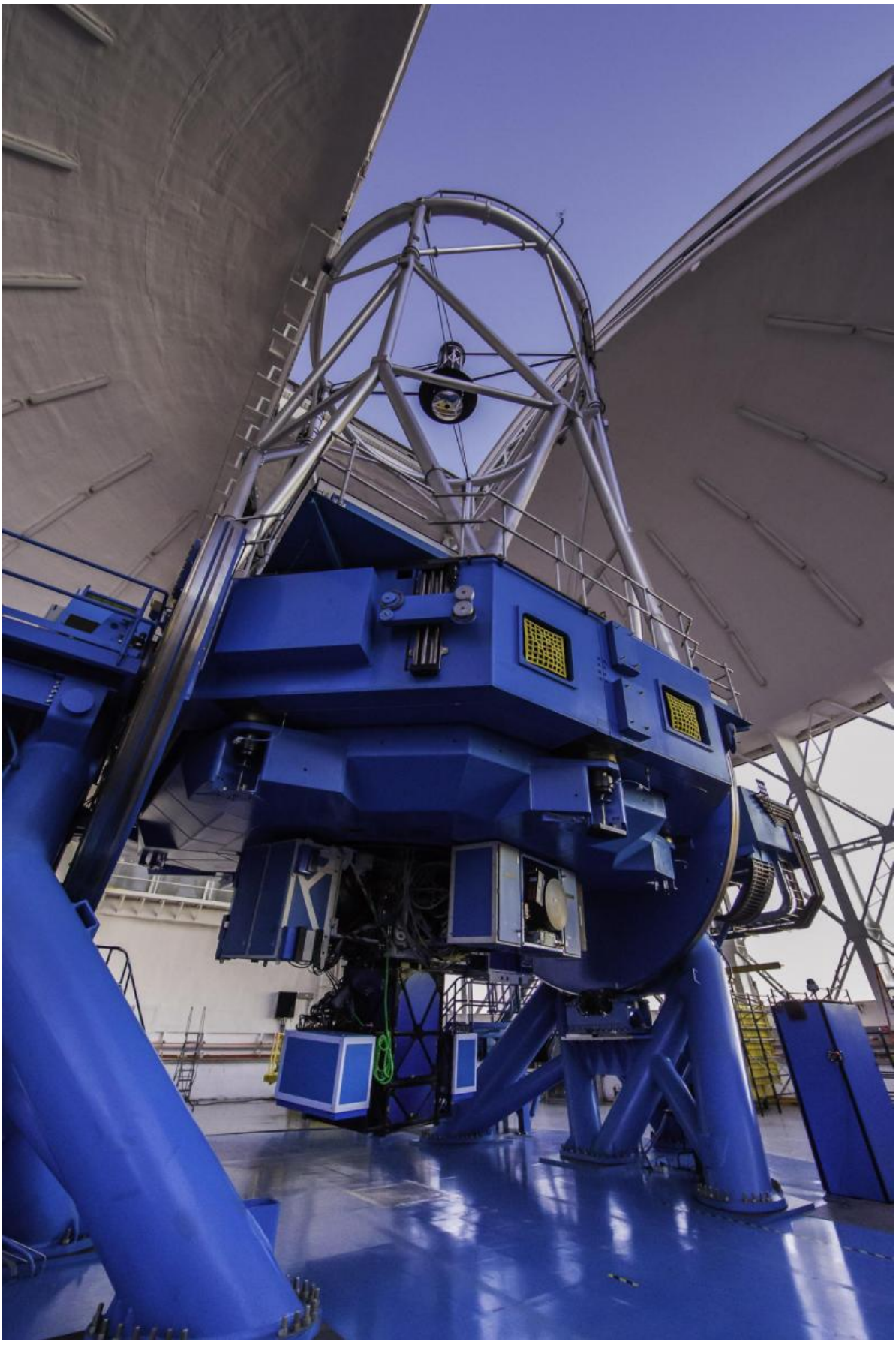
Because the planet and debris disk interact gravitationally, the system provides astronomers with an ideal laboratory to test theories on the formation of planetary systems beyond ours.

Maxwell Millar-Blanchaer, a PhD-candidate in the Department of Astronomy & Astrophysics, University of Toronto, is lead author of a paper to be published September 16th in the *Astrophysical Journal*. The paper describes observations of the β Pictoris system made with the Gemini Planet Imager (GPI) instrument on the Gemini South telescope in Chile.

"The images in the series represent the most accurate measurements of the planet's position ever made," says Millar-Blanchaer. "In addition, with GPI, we're able to see both the disk and the planet at the exact same time. With our combined knowledge of the disk and the planet we're

really able to get a sense of the planetary system's architecture and how everything interacts."

The paper includes refinements to measurements of the exoplanet's orbit and the ring of material circling the star which shed light on the dynamic relationship between the two. It also includes the most accurate measurement of the mass of β Pictoris to date and shows it is very unlikely that β Pic b will pass directly between us and its parent star.



The Gemini Planet Imager on the Gemini South telescope. In the photo, GPI comprises the three box-like components attached to the telescope and hanging closest to the observatory floor. Other box-like components on the telescope are other instruments. Credit: Manuel Paredes/Gemini Observatory/AURA.

Astronomers have discovered nearly two thousand exoplanets in the past two decades but most have been detected with instruments—like the Kepler space telescope—that use the transit method of detection: astronomers detect a faint drop in a star's brightness as an exoplanet transits or passes between us and the star, but do not see the exoplanet itself.

With GPI, astronomers image the actual planet—a remarkable feat given that an orbiting world typically appears a million times fainter than its parent star. This is possible because GPI's adaptive optics sharpen the image of the target star by cancelling out the distortion caused by the Earth's atmosphere; it then blocks the bright image of the star with a device called a coronagraph, revealing the exoplanet.

Laurent Pueyo is with the Space Telescope Science Institute and a co-author on the paper. "It's fortunate that we caught β Pic b just as it was heading back—as seen from our vantage point—toward β Pictoris," says Pueyo. "This means we can make more observations before it gets too close to its parent star and that will allow us to measure its orbit even more precisely."

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Graham (former director of the Dunlap Institute for Astronomy & Astrophysics, U of T).

In August 2015, the team announced its first exoplanet discovery: a young Jupiter-like exoplanet designated 51 Eri b. It is the first exoplanet to be discovered as part of the GPI Exoplanet Survey (GPIES) which will target 600 stars over the next three years.

More information: β Pictoris' inner disk in polarized light and new orbital parameters for β Pictoris b, eprint arXiv:1508.04787. adslabs.org/adsabsadsabs/abs/2015arXiv150804787M/

Provided by Dunlap Institute for Astronomy & Astrophysics