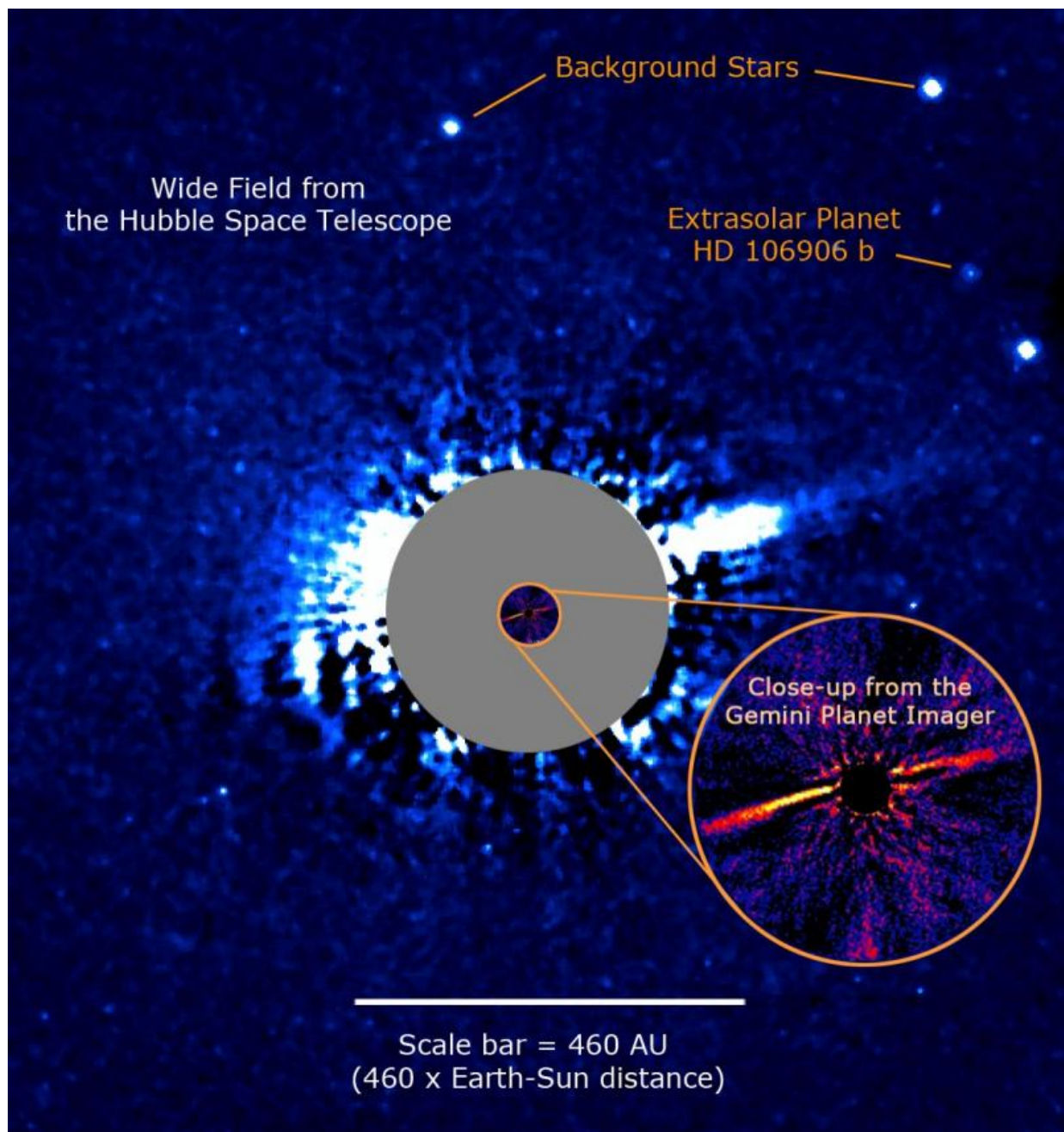


Exiled exoplanet likely kicked out of star's neighborhood

December 1 2015



Two direct images of the cometary dust and exoplanet surrounding the young star HD 106906. The wider field in blue shows Hubble Space Telescope data where the star's blinding light is artificially eclipsed (gray circular mask). The point to the upper right is an 11 Jupiter mass planet located over 650 times the Earth-Sun distance. A new discovery in these Hubble observations is an extremely asymmetric nebulosity indicating a dynamically disturbed system of comets. Surprisingly, the planet is located 21 degrees above the plane of the nebulosity. The circular orange inset shows a region much closer to the star that can only be detected using advanced adaptive optics from the ground-based Gemini Observatory. Using the Gemini Planet Imager (GPI), researchers found a narrow loop of nebulosity suggesting that a planetary system formed close to the star, but somehow the architecture of the outer regions is severely disrupted. The investigators also find that the planet HD 106906b may have a dusty ring system of its own, motivating future work with Hubble and ground-based astronomical observatories. Credit: Paul Kalas, UC Berkeley

A planet discovered last year sitting at an unusually large distance from its star - 16 times farther than Pluto is from the sun - may have been kicked out of its birthplace close to the star in a process similar to what may have happened early in our own solar system's history.

Images from the Gemini Planet Imager (GPI) in the Chilean Andes and the Hubble Space Telescope show that the star has a lopsided comet belt indicative of a very disturbed solar system, and hinting that the planet interactions that roiled the comets closer to the star might have sent the exoplanet into exile as well.

The planet may even have its own ring of debris that it dragged along with it.

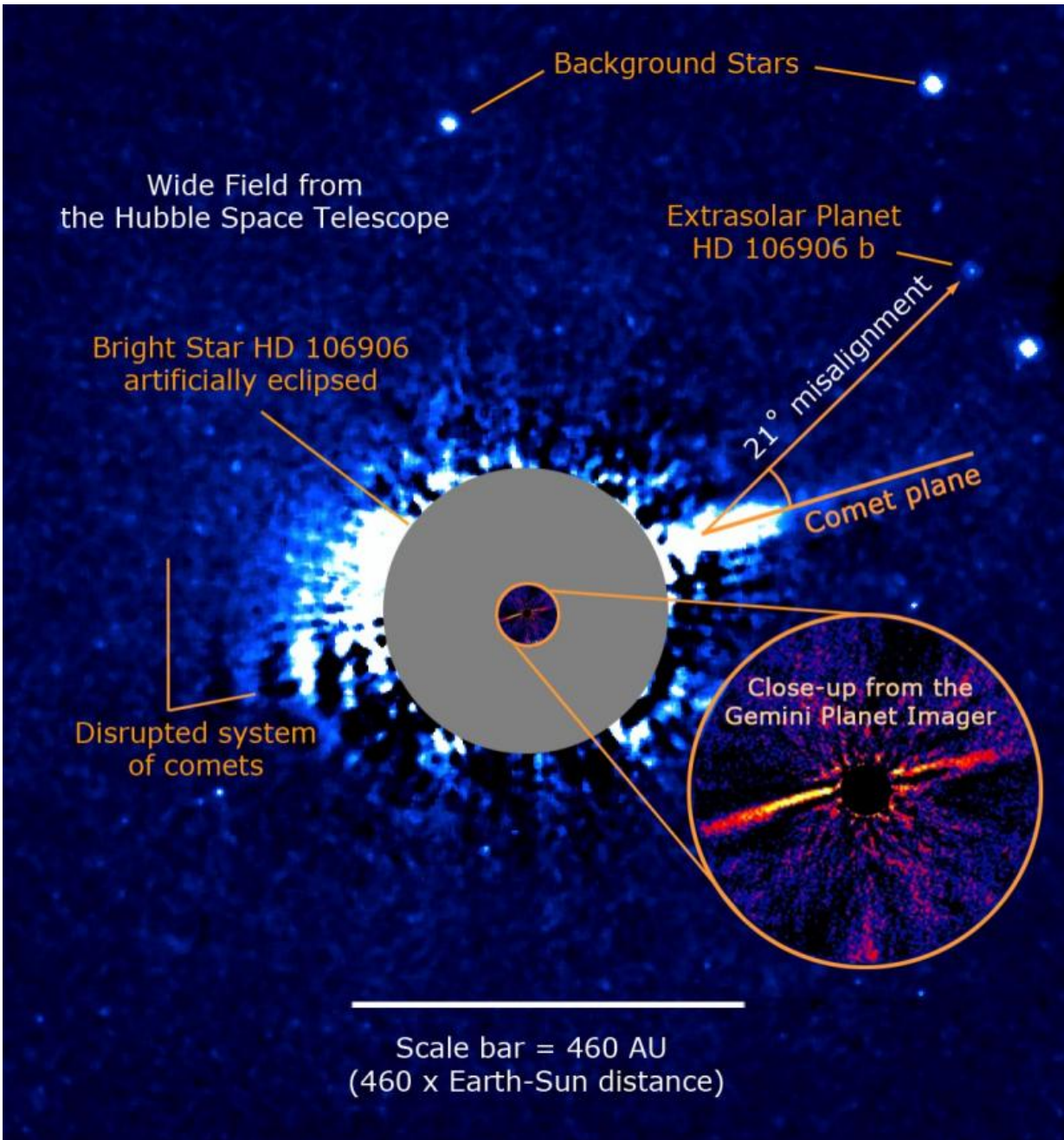
"We think that the planet itself could have captured material from the comet belt, and that the planet is surrounded by a large dust ring or dust shroud," said Paul Kalas, an adjunct professor of astronomy at the University of California, Berkeley. "We conducted three tests and found tentative evidence for a dust cloud, but the jury is still out."

"The measurements we made on the planet suggest it may be dustier than comparison objects, and we are making follow-up observations to check if the planet is really encircled by a disk - an exciting possibility," added Abhi Rajan, a graduate student at Arizona State University who analyzed the planet images.

Such [planets](#) are of interest because in its youth, our own solar system may have had planets that were kicked out of the local neighborhood and are no longer among of the eight planets we see today.

"Is this a picture of our solar system when it was 13 million years old?" asks Kalas. "We know that our own belt of comets, the Kuiper belt, lost a large fraction of its mass as it evolved, but we don't have a time machine to go back and see how it was decimated. One of the ways, though, is to study these violent episodes of gravitational disturbance around other [young stars](#) that kick out many objects, including planets."

The disturbance could have been caused by a passing star that perturbed the inner planets, or a second massive planet in the system. The GPI team looked for another large planet closer to the star that may have interacted with the exoplanet, but found nothing outside of a Uranus-sized orbit.



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Kalas and Rajan discussed the observations during a Google+ Hangout On Air at 7 a.m. Hawaii time (noon EST) on Dec. 1 during Extreme Solar Systems III, the third in a series of international meetings on exoplanets that this year takes place on the 20th anniversary of the discovery of the first exoplanet in 1995. The hangout can be viewed via YouTube.

A paper about the results, with Kalas as lead author, was published in the *The Astrophysical Journal* on Nov. 20, 2015.

Young, 13-million-year-old star

The star, HD 106906, is located 300 light years away in the direction of the constellation Crux and is similar to the sun, but much younger: about 13 million years old, compared to our sun's 4.5 billion years. Planets are thought to form early in a star's history, however, and in 2014 a team led by Vanessa Bailey at the University of Arizona discovered a planet HD 106906 b around the star weighing a hefty 11 times Jupiter's mass and located in the star's distant suburbs, an astounding 650 AU from the star (one AU is the average distance between Earth and the sun, or 93 million miles).

Planets were not thought to form so far from their star and its surrounding protoplanetary disk, so some suggested that the planet formed much like a star, by condensing from its own swirling cloud of gas and dust. The GPI and Hubble discovery of a lopsided comet belt and possible ring around the planet points instead to a normal formation within the debris disk around the star, but a violent episode that forced it into a more distant orbit.

Kalas and a multi-institutional team using GPI first targeted the star in search of other planets in May 2015 and discovered that it was surrounded by a ring of dusty material very close to the size of our own solar system's Kuiper Belt. The emptiness of the central region - an area about 50 AU in radius, slightly larger than the region occupied by planets in our solar system - indicates that a planetary system has formed there, Kalas said.

He immediately reanalyzed existing images of the star taken earlier by the Hubble Space Telescope and discovered that the ring of dusty material extended much farther away and was extremely lopsided. On the side facing the planet, the dusty material was vertically thin and spanned nearly the huge distance to the known planet, but on the opposite side the dusty material was vertically thick and truncated.

"These discoveries suggest that the entire planetary system has been recently jostled by an unknown perturbation to its current asymmetric state," he said. The planet is also unusual in that its orbit is possibly tilted 21 degrees away from the plane of the inner planetary system, whereas most planets typically lie close to a common plane.

Kalas and collaborators hypothesized that the planet may have originated from a position closer to the comet belt, and may have captured dusty material that still orbits the planet. To test the hypothesis, they carefully analyzed the GPI and Hubble observations, revealing three properties

about the planet consistent with a large dusty ring or shroud surrounding it. However, for each of the three properties, alternate explanations are possible.

The investigators will be pursuing more sensitive observations with the Hubble Space Telescope to determine if HD 106906b is in fact one of the first exoplanets that resembles Saturn and its ring system.

The inner belt of dust around the star has been confirmed by an independent team using the planet-finding instrument SPHERE on the ESO's Very Large Telescope in Chile. The lopsided nature of the debris disk was not evident, however, until Kalas called up archival images from Hubble's Advanced Camera for Surveys.

The GPI Exoplanet Survey, operated by a team of astronomers at UC Berkeley and 23 other institutions, is targeting 600 young [stars](#), all less than approximately 100 million years old, to understand how planetary systems evolve over time and what planetary dynamics could shape the final arrangement of planets like we see in our [solar system](#) today. GPI operates on the Gemini South telescope and provides extremely high-resolution, high-contrast direct imaging, integral field spectroscopy and polarimetry of exoplanets.

Provided by University of California - Berkeley

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