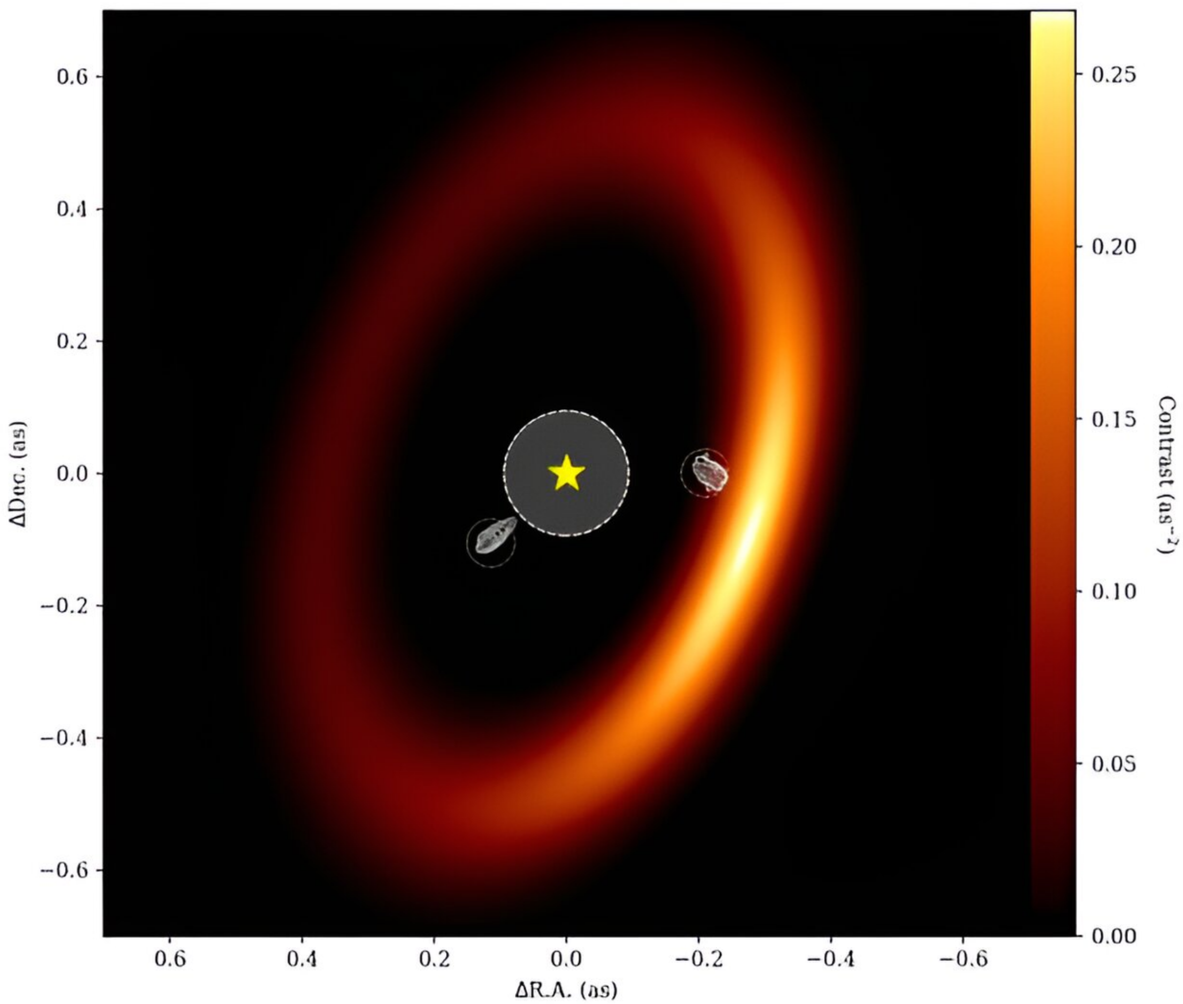
JWST uses interferometry mode to reveal two protoplanets around a young star

April 30 2024, by Evan Gough



The PDS 70 system as seen by the JWST's interferometry mode and after extensive data processing. A yellow star marks the location of PDS 70, with PDS 70 b and c also shown. The JWST shows the infrared emissions coming from the disk. Credit: Blakely et al, *arXiv* (2024). DOI: 10.48550/arxiv.2404.13032

The JWST is flexing its muscles with its interferometry mode. Researchers used it to study a well-known extrasolar system called PDS 70. The goal? To test the interferometry mode and see how it performs when observing a complex target.

The mode uses the telescope's NIRISS (Near Infrared Imager and Slitless Spectrograph) as an interferometer. It's called Aperture Masking Interferometry (AMI) and it allows the JWST to reach its highest level of spatial resolution.

A team of astronomers used the JWST's AMI to observe the PDS 70 system. PDS 70 is a young T-Tauri star about 5.4 million years old. At that young age, its protoplanetary disk still surrounds it. PDS 70 is a well-studied system that's caught the attention of astronomers. It's unique because its two planets, PDS 70 b and c, make it the only multiplanet protoplanetary disk system we know of.

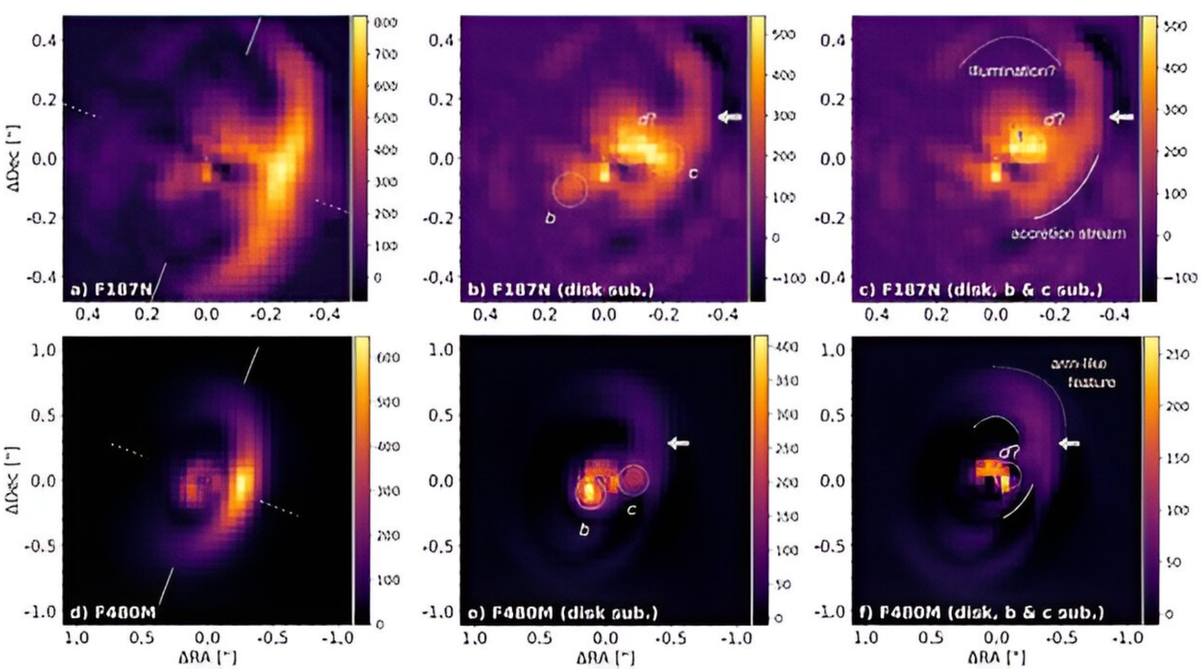
The researchers wanted to determine how easily the AMI would find PDS 70's two known planets and what else it could observe in the system.

Their research article is titled "The James Webb Interferometer: Space-based interferometric detections of PDS 70 b and c at 4.8 μm." It's available on the preprint server *arXiv* and hasn't been peer-reviewed yet. The lead author is Dori Blakely from the Department of Physics and Astronomy at the University of Victoria, BC, Canada.

PDS 70 is known for its pair of planets. PDS 70 b is about 3.2 Jupiter masses and follows a 123-year orbital period. PDS 70 c is about 7.5 Jupiter masses and follows a 191-year orbit. One of the most puzzling things about the system is that PDS 70 b appears to have its own accretion disk. The system also shows intriguing evidence of a third body, maybe another star.

The JWST's interferometry easily detected both planets. In fact, the observations found evidence of circumplanetary disk emissions around PDS 70 b and c. "Our photometry of both PDS 70 b and c provide evidence for circumplanetary disk emission," the researchers write.

That means we can see the star and its protoplanetary disk, where planets form, and the individual circumplanetary disks around each planet. Those disks are where moons form, and seeing them in a system 366 light-years away is very impressive.



These images are from previous research that used the JWST but not its interferometry mode. The top row is from the telescope’s F187N filter, and the bottom row is from the telescope’s F480M filter. The left column shows the complete images. The middle column shows the system with the disk subtracted. The right column shows the system with the disk and both known planets extracted. What remains is a potential third planet, planet “d,” and an arm-like feature and potential accretion stream. Credit: V. Christiaens et al, *arXiv* (2024). DOI: 10.48550/arxiv.2403.04855

The JWST's AMI observations also found a third point source. Its light is different from the light from the pair of planets and more similar to the light from the star. If it's another planet, its composition is different from the others. If it's not another planet, that doesn't mean it necessarily has to be another star. The JWST could be seeing scattered starlight from another gaseous, dusty structure or clump in the disk.

"This indicates that what we observe is not due to a simple inner disk structure, and may hint at a complex inner disk morphology such as a spiral or clumpy features," the researchers explain.

The unexplained third source could be something more exotic. Previous research also identified the source and suggested that it could be an accretion stream flowing between PDS 70 b and c. "We interpret its signal in the direct vicinity of planet c as tracing the accretion stream feeding its circumplanetary disk," the authors of the previous research wrote.

Or, perhaps most exciting, the source could be another planet. "Another scenario is that the signal we observe is due to an additional planet interior to the orbit of PDS 70 b," the authors explain. "Follow-up observations will be needed to determine the nature of this emission," the authors write.

Part of the observations' success comes from what it didn't detect. Protoplanetary disks are dusty and difficult to examine. The JWST has a leg up on it because it can see infrared light. When used in interferometry mode, it's a powerful tool. The fact that it failed to detect any other planets is progress, though. "Additionally, we place the deepest constraints on additional planets," in part of the disk. These constraints will help future researchers examine the PDS 70 system and other extrasolar systems.

The results also show another of AMI's strengths: its ability to see into parts of the parameter space that other telescopes can't. "Furthermore, our results show that NIRISS/AMI can reliably measure relative astrometry and contrasts of young planets in a part of parameter space (small separations and moderate to high contrasts) that is unique to this observing mode, and inaccessible to all other present facilities at 4.8 μm," the authors explain.

The JWST has already established its place in the history of astronomy. It's delivered on its promise and has already significantly contributed to our understanding of the cosmos. The telescope's observations with its Aperture Masking Interferometry mode will further cement its place in history.

"Here, using the power of the James Webb Interferometer, we detect PDS 70, its outer disk, and its two protoplanets, b and c. These are the first planets detected with space-based interferometry," the authors write.

More information: Dori Blakely et al, The James Webb Interferometer: Space-based interferometric detections of PDS 70 b and c at 4.8 μm, *arXiv* (2024). DOI: 10.48550/arxiv.2404.13032

Provided by Universe Today