Hubble Observes 'Flapping' Shadow of HBC 672's Planet-Forming Disk

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Astronomers using the NASA/ESA Hubble Space Telescope have captured striking images of HBC 672's unseen protoplanetary disk casting a huge shadow across a more distant cloud in a star-forming region.


This Hubble image shows the Serpens Nebula, a stellar nursery about 1,300 light-years away. Within the nebula, in the upper right of the image, a shadow is created by the protoplanetary disk surrounding HBC 672. While the disk of debris is too tiny to be seen even by Hubble, its shadow is projected upon the cloud in which it was born. In this view, the feature, the Bat Shadow, spans approximately 200 times the diameter of our own Solar System. Image credit: NASA / ESA / STScI.

HBC 672 resides in a star-forming region called the Serpens Nebula, about 1,300 light-years away.

Hubble captured a striking observation of the star's planet-forming disk in 2018.

This disk casts a huge shadow across a more distant cloud in the star-forming region — like a fly wandering into the beam of a flashlight shining on a wall.

The phenomenon may be caused by a planet pulling on the disk and warping it.

"You have a star that is surrounded by a disk, and the disk is not like Saturn's rings — it's not flat. It's puffed up," said Dr. Klaus Pontoppidan, an astronomer at the Space Telescope Science Institute.

"And so that means that the light from the star, if it goes straight up, can continue straight up — it's not blocked by anything."

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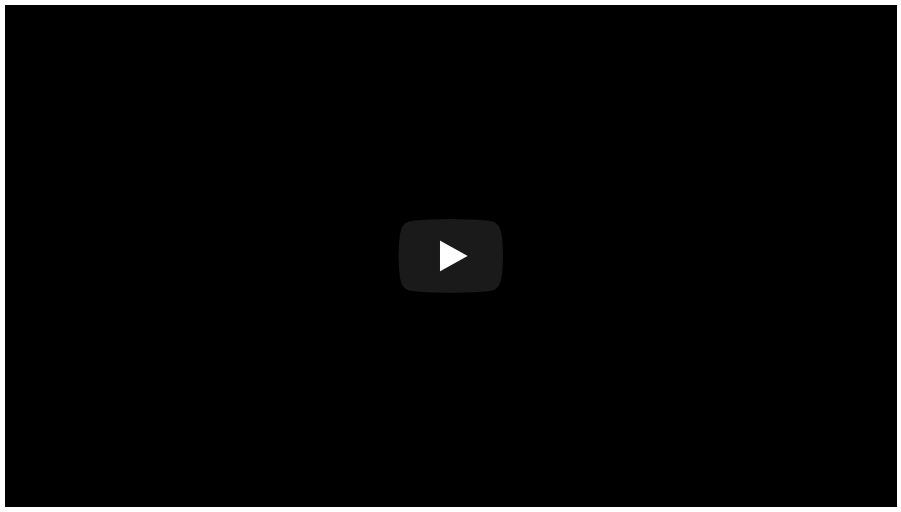
"But if it tries to go along the plane of the disk, it doesn't get out, and it casts a shadow."



This 'flapping' finding was also a surprise. Dr. Pontoppidan and colleagues observed the shadow in several filters over 404 days. When they combined the old and new images, the shadow appeared to have moved.

The shadow is so large — about 200 times the diameter of our Solar System — that light doesn't travel instantaneously across it.

In fact, it takes about 45 days for the light to travel from the star out to the best defined edge of the shadow.

The astronomers calculate that a planet warping the disk would orbit HBC 672 in no fewer than 180 days.

They estimate that it would be about the same distance from its star as Earth is from the Sun.

"The disk must be flared, with an angle that increases with distance — like a trumpet. This shape of its two peaks and two dips would explain the 'flapping' of the shadow," they said.

"A planet is embedded in the disk, inclined to the disk's plane. If it's not a planet, a less likely explanation is a lower-mass stellar companion orbiting HBC 672 outside the plane of the disk."

The researchers doubt this is the case, based on the thickness of the disk. There is also no current evidence for a binary companion.

The disk is a circling structure of gas, dust, and rock, and is too small and too distant to be seen, even by Hubble. However, based on the projected shadow, the scientists do know that its height-to-radius ratio is 1:5.

The findings will be published in the *Astrophysical Journal*.

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Klaus M. Pontoppidan *et al.* 2020. Variability of the Great Disk Shadow in Serpens. *ApJ*, in press; arXiv: 2006.05965

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