ALMA telescope shows how young star and planets grow simultaneously

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Artist's conception of HD142527 system: Gas streamers cross gap in protoplanetary disk. Credit: Bill Saxton, NRAO/AUI/NSF

(Phys.org)—Astronomers have used the ALMA telescope to get their first glimpse of a fascinating stage of star formation in which planets

forming around a young star are helping the star itself continue to grow, resolving a longstanding mystery. The young system, about 450 light-years from Earth, is revealing its complex gravitational dance to the ever-sharpening vision of the Atacama Large Millimeter/submillimeter Array (ALMA), scheduled for completion this year.

As young stars gather material from their surrounding clouds of gas and dust, the incoming material forms a flat, spinning disk around the star. Planets begin as small clumps within that disk that, through their gravitational pull, add to their mass. As the planets pull in more material, they also leave a wake in their trail that clears out a gap in the disk. Such gaps have been observed in the dust disks surrounding a number of still-forming solar systems.

During this process, the star also continues to grow more massive, leading to the question of how material can get through the gap cleared by the protoplanets and onto the star.

"This has been a bit of a mystery, but now we have found a process that allows the star to continue to grow despite the gap," said Simon Casassus, of the University of Chile and the Millennium Nucleus for Protoplanetary Disks, who led an international research team.

First, the scientists found that the gap is not empty, but is filled by thin, tenuous gas, as shown by ALMA detection of carbon monoxide. "Whereas dust is severely depleted within the gap, some residual gas remains," said Gerrit van der Plas, of the University of Chile. "This agrees with predictions for gap clearing by a planetary-mass body," he added.

Next, ALMA revealed streamers of dense gas (HCO+, or Formyl ion) crossing through the gap, bringing material from the outer portion of the disk, near and onto the planets, and into the disk's inner portion, closer to

the star than where planets probably are forming. These streamers, the scientists say, probably are caused by the gravitational pull of the young planets.

"The most natural interpretation for the flows seen by ALMA is that the putative protoplanets are pulling streams of gas inward toward them that are channelled by their gravity. Much of the gas then overshoots the planets and continues inward to the portion of the disk close to the star, where it can eventually fall onto the star itself," Casassus said.

In the system Casassus and his colleagues studied, called HD 142527, they calculated that, without the streamers, the inner portion of the disk would be depleted in less than a year. However, the gas delivered by the streamers is sufficient to maintain the inner disk and the star's observed rate of mass growth.

"Computer simulations indicated that such a process should be happening, and now we've found it," said Sebastian Perez of the University of Chile.

The planets, the scientists said, should be embedded in the dense streams of infalling gas, and likely are several times more massive than Jupiter, the largest planet in our Solar System. The dense gas in the streamers, however, obscures the planets from direct observation.

In the HD 142527 system, the inner disk extends outward from the young star about 10 times the distance from the Sun to the Earth, or just past the orbit of Saturn. The gap extends from there to more than 140 times the Sun-Earth distance. The planets, the scientists said, should lie within the gap, at a distance of about 90 times the Sun-Earth distance.

"The new capabilities provided by ALMA made this work possible, but this is just the beginning," Casassus said of the international millimeter-

wave observatory still under construction in northern Chile.

The research team reported their findings in the scientific journal *Nature*.

More information: This research was presented in a paper, "Flows of gas through a protoplanetary gap", to appear in the journal *Nature* on January 2, 2013.

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