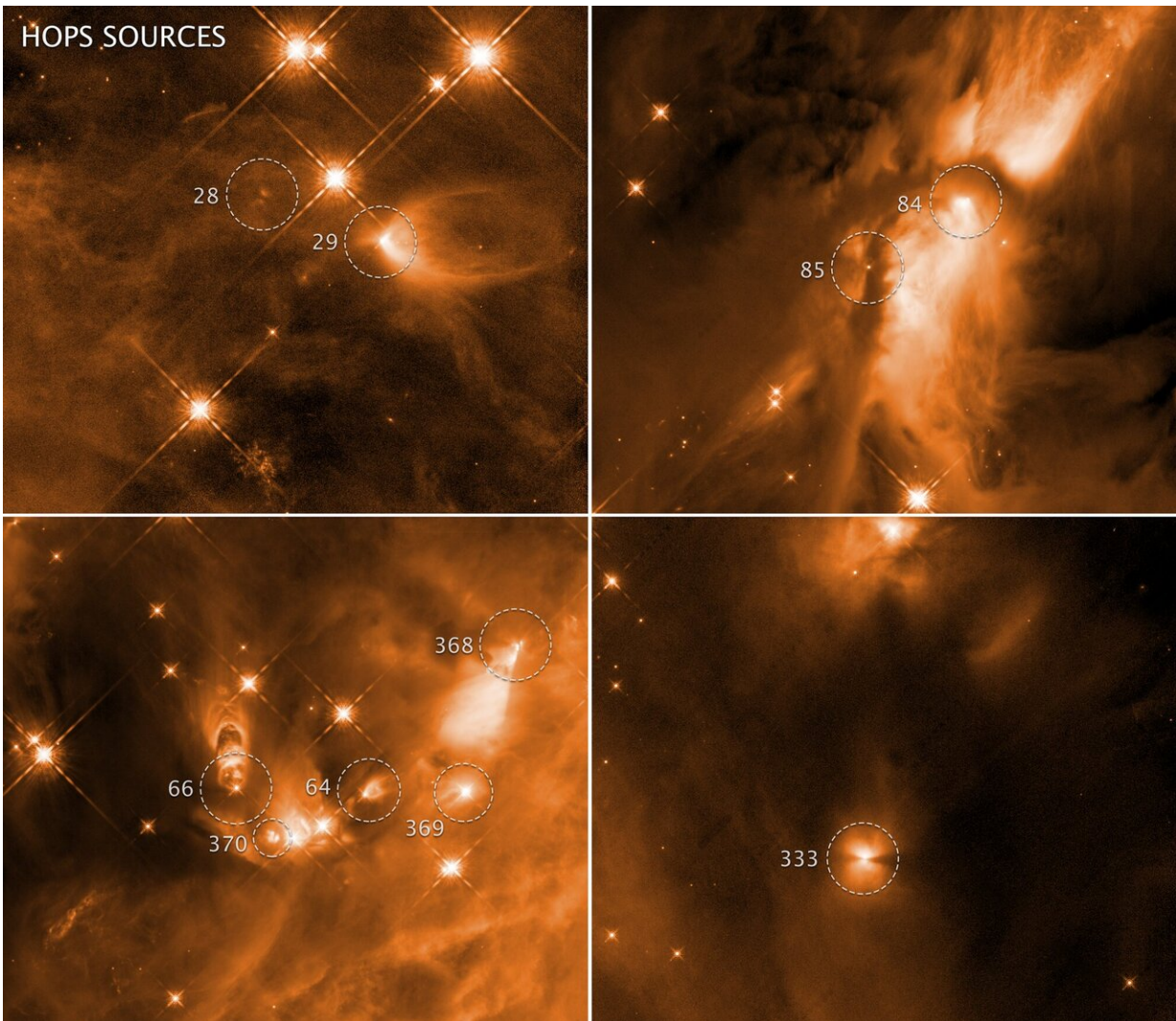


Hubble shows torrential outflows from infant stars may not stop them from growing

March 18 2021



These four images taken by NASA's Hubble Space Telescope reveal the chaotic birth of stars in the Orion complex, the nearest major star-forming region to Earth. The snapshots show fledgling stars buried in dusty gaseous cocoons

announcing their births by unleashing powerful winds and pairs of spinning, lawn-sprinkler-style jets shooting off in opposite directions. Near-infrared light pierces the dusty region to unveil details of the birthing process. The stellar outflows are carving out cavities within the hydrogen gas cloud. This relatively brief birthing stage lasts about 500,000 years. Although the stars themselves are shrouded in dust, they emit powerful radiation, which strikes the cavity walls and scatters off dust grains, illuminating in infrared light the gaps in the gaseous envelopes. Astronomers found that the cavities in the surrounding gas cloud sculpted by a forming star's outflow did not grow regularly as they matured, as theories propose. The young stars in these images are just a subset of an ambitious study of 304 developing stars, the largest-ever to date. Researchers used data previously collected from NASA's Hubble and Spitzer space telescopes and the European Space Agency's Herschel Space Telescope. The protostars were photographed in near-infrared light by Hubble's Wide Field Camera 3. The images were taken Nov. 14, 2009, and Jan. 25, Feb. 11, and Aug. 11, 2010. Credit: NASA, ESA, and N. Habel and S. T. Megeath (University of Toledo)

Stars aren't shy about announcing their births. As they are born from the collapse of giant clouds of hydrogen gas and begin to grow, they launch hurricane-like winds and spinning, lawn-sprinkler-style jets shooting off in opposite directions.

This action carves out huge cavities in the giant gas clouds. Astronomers thought these stellar temper tantrums would eventually clear out the surrounding gas cloud, halting the star's growth. But in a comprehensive analysis of 304 fledgling stars in the Orion Complex, the nearest major star-forming region to Earth, researchers discovered that gas-clearing by a star's outflow may not be as important in determining its final mass as conventional theories suggest. Their study was based on previously collected data from NASA's Hubble and Spitzer space telescopes and the European Space Agency's Herschel Space Telescope.

The study leaves astronomers still wondering why star formation is so inefficient. Only 30% of a hydrogen gas cloud's initial mass winds up as a newborn star.

Though our galaxy is an immense city of at least 200 billion stars, the details of how they formed remain largely cloaked in mystery.

Scientists know that stars form from the collapse of huge hydrogen clouds that are squeezed under gravity to the point where nuclear fusion ignites. But only about 30 percent of the cloud's initial mass winds up as a newborn star. Where does the rest of the hydrogen go during such a terribly inefficient process?

It has been assumed that a newly forming star blows off a lot of hot gas through light-saber-shaped outflowing jets and hurricane-like winds launched from the encircling disk by powerful magnetic fields. These fireworks should squelch further growth of the central star. But a new, comprehensive Hubble survey shows that this most common explanation doesn't seem to work, leaving astronomers puzzled.

Researchers used data previously collected from NASA's Hubble and Spitzer space telescopes and the European Space Agency's Herschel Space Telescope to analyze 304 developing stars, called protostars, in the Orion Complex, the nearest major star-forming region to Earth. (Spitzer and Herschel are no longer operational.)

In this largest-ever survey of nascent stars to date, researchers are finding that gas—clearing by a star's outflow may not be as important in determining its final mass as conventional theories suggest. The researchers' goal was to determine whether stellar outflows halt the infall of gas onto a star and stop it from growing.

Instead, they found that the cavities in the surrounding gas cloud

sculpted by a forming star's outflow did not grow regularly as they matured, as theories propose.



This ground-based image offers a wide view of the entire Orion cloud complex, the closest major star-forming region to Earth. The red material is hydrogen gas ionized and heated by ultraviolet radiation from massive stars in Orion. The stars are forming in clouds of cold hydrogen gas that are either invisible or appear as dark regions in this image. The crescent shape is called Barnard's Loop and partly wraps around the winter constellation figure of Orion the Hunter. The hunter's belt is the diagonal chain of three stars at image center. His feet are the bright stars Saiph (bottom left) and Rigel (bottom right). This landscape encompasses tens of thousands of newly forming stars bursting to life. Many are still encased in their natal cocoons of gas and dust and only seen in infrared light. The undulating line of yellow dots, beginning at lower left, is a superimposed image of 304 nascent stars taken by NASA's Hubble Space Telescope. This landscape encompasses tens of thousands of newly forming stars bursting to life. Many are still encased in their natal cocoons of gas and dust and only seen in infrared light. Researchers used NASA's Hubble and Spitzer space telescopes and the European Space Agency's Herschel Space Telescope to analyze how young stars' powerful outflows carve out cavities in the vast gas clouds. The study is the largest-ever survey of developing stars. Credit: R. B. Andreo, DeepSkyColors.com; Data Overlay: NASA, ESA, STScI, N. Habel and S. T. Megeath (University of Toledo)

"In one stellar formation model, if you start out with a small cavity, as the protostar rapidly becomes more evolved, its outflow creates an ever-larger cavity until the surrounding gas is eventually blown away, leaving an isolated star," explained lead researcher Nolan Habel of the University of Toledo in Ohio.

"Our observations indicate there is no progressive growth that we can find, so the cavities are not growing until they push out all of the mass in the cloud. So, there must be some other process going on that gets rid of the gas that doesn't end up in the star."

The team's results will appear in an upcoming issue of *The Astrophysical Journal*.

A Star is Born

During a star's relatively brief birthing stage, lasting only about 500,000 years, the star quickly bulks up on mass. What gets messy is that, as the star grows, it launches a wind, as well as a pair of spinning, lawn-sprinkler-style jets shooting off in opposite directions. These outflows begin to eat away at the surrounding cloud, creating cavities in the gas.

Popular theories predict that as the young star evolves and the outflows continue, the cavities grow wider until the entire gas cloud around the star is completely pushed away. With its gas tank empty, the star stops accreting mass—in other words, it stops growing.

To look for cavity growth, the researchers first sorted the protostars by age by analyzing Herschel and Spitzer data of each star's light output. The protostars in the Hubble observations were also observed as part of the Herschel telescope's Herschel Orion Protostar Survey.

Then the astronomers observed the cavities in near-infrared light with Hubble's Near-infrared Camera and Multi-object Spectrometer and Wide Field Camera 3. The observations were taken between 2008 and 2017. Although the stars themselves are shrouded in dust, they emit powerful radiation which strikes the cavity walls and scatters off dust grains, illuminating the gaps in the gaseous envelopes in infrared light.

The Hubble images reveal the details of the cavities produced by protostars at various stages of evolution. Habel's team used the images to measure the structures' shapes and estimate the volumes of gas cleared out to form the cavities. From this analysis, they could estimate the amount of mass that had been cleared out by the stars' outbursts.

"We find that at the end of the protostellar phase, where most of the gas has fallen from the surrounding cloud onto the star, a number of young [stars](#) still have fairly narrow cavities," said team member Tom Megeath of the University of Toledo. "So, this picture that is still commonly held of what determines the mass of a star and what halts the infall of gas is that this growing outflow [cavity](#) scoops up all of the gas. This has been pretty fundamental to our idea of how [star formation](#) proceeds, but it just doesn't seem to fit the data here."

Future telescopes such as NASA's upcoming James Webb Space Telescope will probe deeper into a protostar's formation process. Webb spectroscopic observations will observe the inner regions of disks surrounding protostars in infrared light, looking for jets in the youngest sources. Webb also will help astronomers measure the accretion rate of material from the disk onto the star, and study how the inner disk is interacting with the outflow.

More information: An HST Survey of Protostellar Outflow Cavities: Does Feedback Clear Envelopes? arXiv:2102.06717 [astro-ph.GA]
arxiv.org/abs/2102.06717

Provided by ESA/Hubble Information Centre

Citation: Hubble shows torrential outflows from infant stars may not stop them from growing (2021, March 18) retrieved 9 April 2024 from <https://phys.org/news/2021-03-hubble-torrential-outflows-infant-stars.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.
