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A massive star is born: Time-lapse movie shows that massive stars form like their smaller siblings

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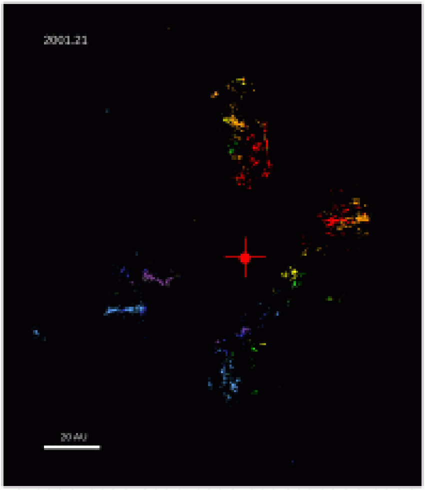
Artist's conception of the rotating disk of hot, ionized gas surrounding Orion Source I, blocking the star from our view. A cool wind of gas is driven from the upper and lower surfaces of the disk and is sculpted into an hourglass shape by tangled magnetic field lines. Image: Bill Saxton, National Radio Astronomy Observatory/Associated Universities, Incorporated/National Science Foundation

(PhysOrg.com) -- A team of astronomers led by Lynn D. Matthews at the MIT Haystack Observatory has discovered a disk of gas swirling close to a young massive star, which they say offers the first evidence that massive stars form similarly to smaller stars. Because massive stars are believed to be responsible for creating most of the chemical elements in the universe that are critical for the formation of Earth-like planets and life, understanding how they form may help unravel mysteries about the origins of life.

Until now, it had been difficult to prove how massive stars form because they are rare, form very quickly and tend to be enshrouded in dense, dusty material, making it hard to observe them. By using the National Science Foundation's Very Long Baseline Array (VLBA) radio telescope to take images of the wavelengths of light emitted by a massive young star located 1,350 light years away in the Orion constellation, Matthews' team has produced a high-resolution time-lapse movie that reveals a disk rotating around the star, known as Source I (when spoken, "Source Eye").

"It is the first really ironclad confirmation that massive young stars are surrounded by orbiting accretion disks, and the first strong suggestion that these disks launch magnetically driven winds," said University of California at Santa Cruz astronomy and astrophysics professor Mark Krumholz of the time-lapse movie, which is described in a paper published in the Jan. 1 issue of the Astrophysical Journal.

For almost 20 years, astronomers have known that low-mass stars form as a result of disk-mediated accretion, or from material formed from a structure rotating around a central body and driven by magnetic winds. But it had been impossible to confirm whether this was true for massive stars, which are eight to 100 times larger than low-mass stars. Without any hard data, theorists proposed many models for how massive stars might form, such as via collisions of smaller stars. "This work should rule out many of them," Krumholz said of Matthews' movie.



Movie created from real data collected by Matthews' team showing the motions of gas clumps around Source I over the course of 22 months. The gas emission is color-coded according to the velocity of the material. Video: Matthews et al. (Click 'Enlarge' for animation)

Piercing the Dusty Cloud

A network of 10 radio telescope dishes located across North America, the VLBA can be thought of as a virtual telescope 5,000 miles in diameter, according to Matthews. Used as a zoom lens to penetrate the dusty cloud surrounding the massive star, the VLBA captured images up to 1,000 times sharper than those previously obtained by other telescopes, including NASA's Hubble Space Telescope.

By assembling 19 individual images of Source I taken by the VLBA at monthly intervals between March 2001 and December 2002, the high-resolution movie reveals thousands of masers, radio emitting gas clouds that can be thought of as naturally occurring lasers, located close to the massive star. According to Matthews, only three massive stars in the entire galaxy are known to have silicon monoxide masers. Because the silicon monoxide masers emit beams of intense radiation that can pierce the dusty material surrounding Source I, the scientists could probe the material close to the star and measure the motions of individual gas clumps.

By tracking the gas motions through space, the astronomers discovered the rotating accretion disk comprised of gas clumps orbiting the central star, as well as clumps moving away from it that appear to be caught in an outflowing wind. Such gas outflows help form stars by carrying momentum away from the system.

One interesting implication of the masers near Source I is that some gas particles appear to move away from the massive star along curved trajectories that wrap in a helix shape resembling Twizzlers candy. “To induce that kind of curvature, our observations seem to suggest, there is some role of magnetic fields during this process,” Matthews said.

To better understand this possible magnetic field, researchers plan to measure the polarization of the light from gas around the star, which will help them quantify its strength and geometry. The group would also like to extend the time span of the movie to several years to see the evolution of the material around the star over longer time scales.

“Full-motion movies are actually quite rare in astronomy,” Krumholz said. “With a few exceptions, most processes take place much too slowly for noticeable changes to occur over a human lifetime.”

Matthews’ team includes scientists from the Harvard-Smithsonian Center for Astrophysics, the National Radio Astronomy Observatory and the University of Illinois at Urbana-Champaign, Department of Physics.

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