ASTRONOMY

Crash and Burn: Propagating New Massive Stars

Two cold, dead clouds of interstellar gas collide. Almost instantaneously, shock waves begin to pack matter into lumps. Gravity draws the matter ever tighter. The lumps pass a critical threshold of density and, puff, thousands of newborn stars light up.

That's one picture theorists have painted of the birth of the biggest, brightest stars—those with more than 10 times the mass of the sun. Now astronomers have seen the process in action, says Tetsuo Hasegawa of the University of Tokyo. At the October meeting of the Japan Astronomical Society in Nagoya, Hasegawa announced that he and his collaborators Fumio Sato of Tokyo Gakugei University, John Whiteoak of the Australian National Telescope Facility, and Ryosuke Miyawaki of Fukuoka University of Education have mapped the collision of two massive clouds some 25,000 light-years away, near the center of our galaxy. Right at the collision point they find a nest of newborn massive stars—evidence for a violent birth process that may go on throughout the galactic center and in distant young galaxies.

Hasegawa and his colleagues traced the collision by using the 45-meter radio telescope at the Nobeyama Observatory to map radio waves emitted by carbon monoxide molecules in the clouds. Doppler shifts in the emissions revealed one cloud that is moving at 70 to 80 kilometers per second away from Earth; at that rate, it should be overtaking and crashing into a second cloud, moving at only 30 to 40 kilometers per second. Indeed, the radio maps suggest that just such a collision is well under way: The slower cloud is speeding up at the presumed point of impact, and a cavity has opened up in it—possibly a sort of crater carved out by shock waves. And in and around the collision zone, the radio maps reveal more than 10 concentrated sources of radio waves where gas has been set aglow, the researchers think, by newborn massive stars.

The results join earlier, less direct evidence for the collision scenario: Other astronomers, for example, had found nests of new stars just where the velocity of a molecular cloud takes a jump, as if two gas streams were colliding. But astronomer Bruce Elmgreen of the Harvard-Smithsonian Center for Astrophysics calls Hasegawa's detailed evidence for the collision scenario "a great step forward."

Even so, the evidence isn't watertight, Elmgreen warns. The problem, he says, is that you can't tell the relative positions of the clouds—"You don't know what's foreground and what's background." If the slower cloud lies in the path of the faster one, as Hasegawa's group believes, a collision is guaranteed. But what if the positions are reversed and the faster cloud is pulling away from the slower one rather than colliding with it? Hasegawa responds that the close match between the edges of the clouds tells the story—"It's as convincing as the match of continental coasts that inspired Alfred Wegener [the father of continental drift]," he says.

If Hasegawa and his colleagues are right, adds astronomer John Bally of the University of Colorado, Boulder, they've caught a glimpse of a process that could account for some of the most mysterious displays in the sky. The Infrared Astronomical Satellite (IRAS), for example, has detected several distant, presumably young galaxies that shine abnormally brightly in infrared radiation—some 100 times brighter than our Milky Way.

One possible explanation is a case of virulent star formation, Bally says. Not all of it need be triggered by collisions; supernovas or the "wind" from existing massive stars, theorists believe, can also shock gas clouds and spawn massive stars. And some gas clouds probably collapse and form stars without any urging, though such slower collapses are likely to produce small stars of about the mass of the sun (see box). But in the turbulent environment of a young galaxy, cloud collisions could account for many of the massive stars that make such galaxies shine so brightly.

Even a mature galaxy like our own might harbor some youthful turmoil at its center. Astronomers suspect that prolific starbirth throughout the center of the galaxy may account for its powerful infrared and radio emissions, says Bally. Besides the Sagittarius B2 region, which Hasegawa's group studied, other giant gas clouds are jostling in the galactic center. Their collisions, it seems, may be stoking the galaxy's central fire.

–Fred Myers and Faye Flam

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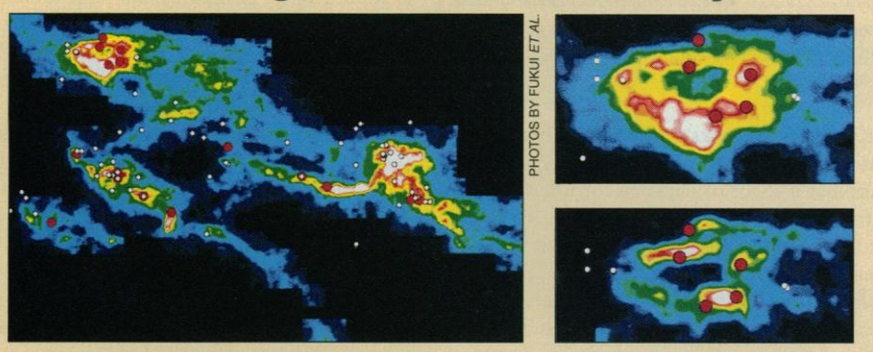
Looking Into a Stellar Nursery



Pregnant with stars. A radio map of carbon monoxide in the Taurus clouds shows dense regions *(white and red)* that are spawning stars *(red and white circles)*. At right are closeups of one region in ^{13}CO *(top)* and in a rarer form, $C^{18}O$.

While one group of astronomers at the Japan Astronomical Society meeting focused on what triggers starbirth (see main story), another offered a close look at the process itself. For their case study, Yasuo Fukui of Nagoya University and his colleagues chose a dense complex of gas clouds in Taurus, just 400 light-years away. Buried in the gas clouds, which are slowly collapsing under their own gravity, astronomers had already identified some 50 young stars of about the same mass as the sun. Fukui and his group set out to see how fast such stars are born.

They couldn't follow a single cloud all the way through to the emergence of a new star, of course. But by taking an inventory of all the star-forming regions in the complex, Fukui and his colleagues were able to come up with a timescale. They began by making a survey of the clouds' density, based on radio emissions from a rare form of interstellar carbon monoxide containing the isotope carbon-13. To peer into denser regions, where even that form of the gas is so abundant that signals can't escape, the researchers resorted to a still rarer form containing oxygen-18. The number of regions in different stages of star-forming collapse revealed how long the process of starbirth takes. Fukui estimates that it takes about 500,000 to a million years for the gas to start coalescing into a star. After that it's a mere 50,000 to 100,000 years before the newborn star winks on.

–F.M. and F.F.