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PRESS RELEASE (2025/04/02)

Star light, star bright, baby stars blow rings alight
Using ALMA, astronomers observe protostars producing rings of gas and magnetic flux as they grow

Fukuoka, Japan—Researchers have uncovered new insights into the early development of baby stars. Publishing in *The Astrophysical Journal Letters,* a research team from Kyushu University and Kagawa University reports that during the early growth period of a baby star, the protostellar disk—the dense disk of gas and dust that surrounds the star—expels magnetic flux and forms a giant warm ring of gas about 1,000 au (astronomical units) in size. The research team explains that these "sneezes" of matter and magnetic energy help the baby star release excess energy, leading to proper star formation.

One of the many mysteries that the universe holds is how stars like our Sun are born. Stars are born in areas of the cosmos called stellar nurseries, where gas and dust coalesce to form early stars called protostars. The best way to understand star formation is to observe these stellar nurseries; however, this can be difficult due to the aforementioned gas and dust obscuring the baby star.

"Thankfully, one of the most promising ways to get a clear view of protostars is to use the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile," explains Professor Masahiro N. Machida of Kyushu University's Faculty of Science, who led the study. "This radio telescope lets us see the different materials that make up stellar nurseries."

Over the last decade, the team has been using ALMA to study the protostars in the stellar nursery in the Taurus Molecular Cloud. Our Sun is about 4.6 billion years old, and a star is considered a "newborn" if it's around 100,000 years old. The baby star the team studied is younger than that.

In their previous research, the team found that the protostellar disk of a baby star forms spike-like structures approximately 10 au in size through magnetic activity. These "sneezes," as the researchers describe them, are critical for ejecting excess energy from the baby star. In their new findings, the team collected data on the molecular cloud core MC 27 and discovered a much larger ring-shaped gas structure 1,000 au in size near the baby star.

"Our data showed that this ring is slightly warmer than its surroundings. We hypothesize that it is produced through a magnetic field threading the protostellar disk. In essence, the "sneezes" we've observed in the past, but at a much bigger scale," explains first author Kazuki Tokuda from Kagawa University. "The warm ring we detected this time strengthens our hypothesis that baby stars undergo dynamic magnetic-gas redistribution shortly after birth, generating shock waves that warm the surrounding gas."

The team intends to gather more high-resolution images from ALMA to see what is inside these rings and understand the nature of the phenomenon. Moreover, since this is their first study, they plan to search the ALMA archive for more data on baby stars in different regions of the universe.

"We were very surprised by these results because we didn't expect to find such a clear ring. I

was so excited that I drafted this paper in two to three days," continues Tokuda.

Machida concludes, "We will keep collecting data to strengthen our hypothesis. In the meantime, we welcome rigorous debate on our results so we can advance our field. The gas motion involved in star formation is generally ordered, yet very chaotic, appearing in different shapes and sizes. It took us a decade to reach these conclusions, and we look forward to doing more work to uncover the mysteries of the universe."

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For more information about this research, see "ALMA Band 9 CO (6–5) Reveals a Warm Ring Structure Associated with the Embedded Protostar in the Cold Dense Core MC 27/L1521F," Kazuki Tokuda, Mitsuki Omura, Naoto Harada, Ayumu Shoshi, Naofumi Fukaya, Toshikazu Onishi, Kengo Tachihara, Kazuya Saigo, Tomoaki Matsumoto, Yasuo Fukui, Akiko Kawamura, and Masahiro N. Machida *The Astrophysical Journal Letters*, https://doi.org/10.3847/2041-8213/ae47ec

About Kyushu University
Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutions of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World Rankings. Located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands—Kyushu U sits in a coastal metropolis frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Its multiple campuses are home to around 19,000 students and 8,000 faculty and staff. Through its VISION 2030, Kyushu U will "drive social change with integrative knowledge." By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society's most pressing issues.

About Kagawa University
Kagawa University is located in Takamatsu, Kagawa Prefecture, on the island of Shikoku—Japan's smallest of the four main islands—and sits in a coastal city known for its mild climate and close connection to the Seto Inland Sea. Kagawa University boasts six faculties and six graduate schools, currently educating about 5,600 undergraduate students and around 900 graduate students. The history of Kagawa University dates back to 1949, when it was founded as a national university with two faculties: the Faculty of Economics, which originated from Takamatsu College of Economics, and the Faculty of Education, which was based on the Kagawa Normal School and Kagawa Normal School for Youth. Subsequent expansions led to the establishment of the Faculty of Agriculture in 1955, the Faculty of Law in 1981, and the Faculty of Engineering in 1987. Furthermore, in 2003, Kagawa University was reborn as the new Kagawa University through a merger with Kagawa Medical University, founded in 1980.

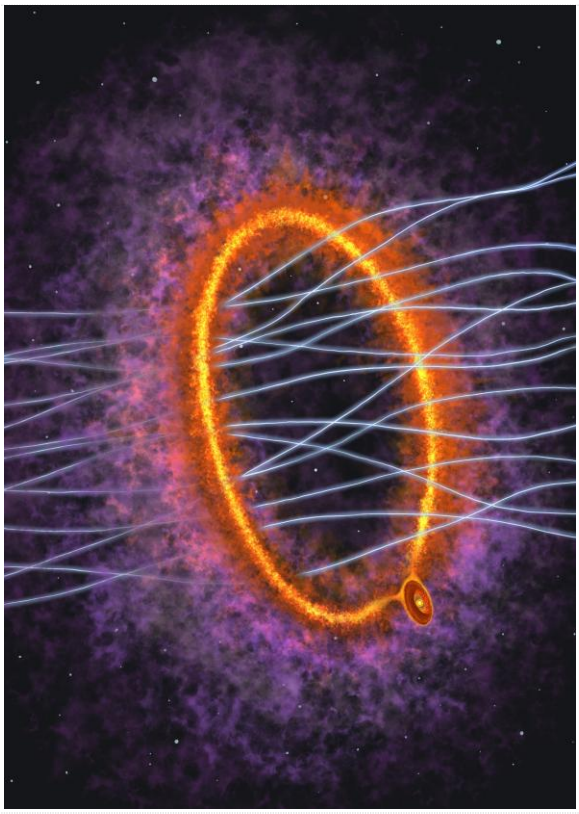

Fig. 1. The ring produced by MC 27. An artist's rendering of the molecular cloud core MC 27 based on observations from the ALMA telescope. The protostar and the disk surrounding it are shown in the lower right, with warm gas extending outward in a ring-like structure, with magnetic field lines penetrating the interior of the ring. (Y. Nakamura, K. Tokuda et al.)

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