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Birth of high mass stars and the origin of life

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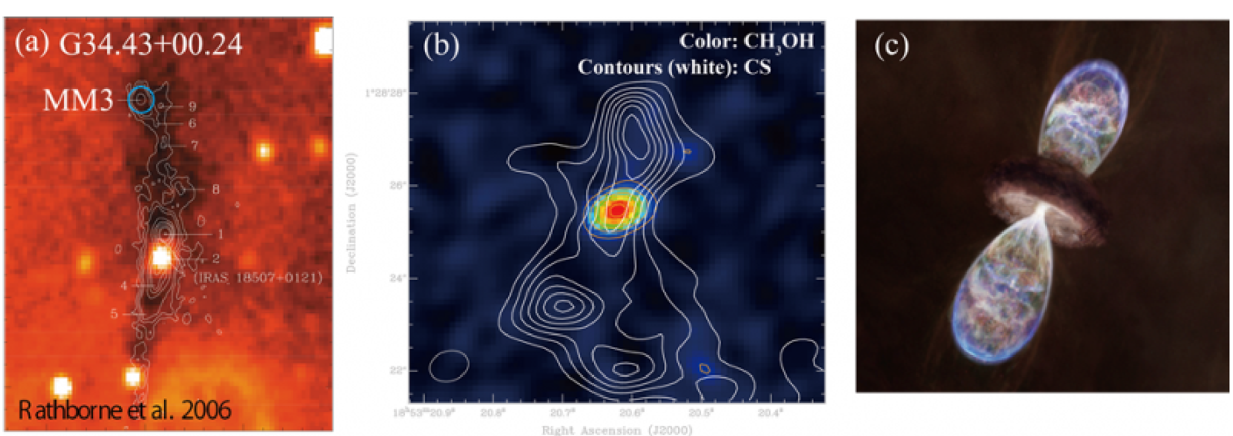
Atacama Large Millimeter/Submillimeter Array (ALMA) facilities in Chile

Takeshi Sakai, Assistant Professor, Graduate School of Informatics and Engineering, discusses recent work. "I am using the Atacama Large Millimeter/Submillimeter Array (ALMA) facilities in Chile to study the formation of stars," says Sakai. "In particular I am looking at 'high-mass' stars formed in clusters that are approximately 10,000 light years from the Earth. High mass stars play an important role in the evolution of galaxies and ultimately hold the secrets of the origins of life on Earth."

Interest in the formation of stars in clusters stems from research that indicates that 70-90% of stars in our galaxy are born in clusters. In contrast to high mass stars, there is much more knowledge about low mass stars because at 400 light years away, they are located much closer to Earth and more readily accessible with telescopes.

The radio telescopes at ALMA are located at approximately 5000 m above sea level in Atacama, Chile, where the air is dry with minimal absorption of weak infra-red signature signals of the chemical composition of the clusters where high mass stars are born.

"Our telescopes enable us to map the evolution of the chemical compositions of molecular clouds," explains Sakai. "So we are able to detect the very early stages of star formation by looking for changes in the chemical species of molecular clouds." For example, the core of a diffuse cloud may be composed of only ionized carbon but chemical spectra of a dense cloud will show signals from carbon monoxide/ammonia, and complex organic molecules when a star is formed.



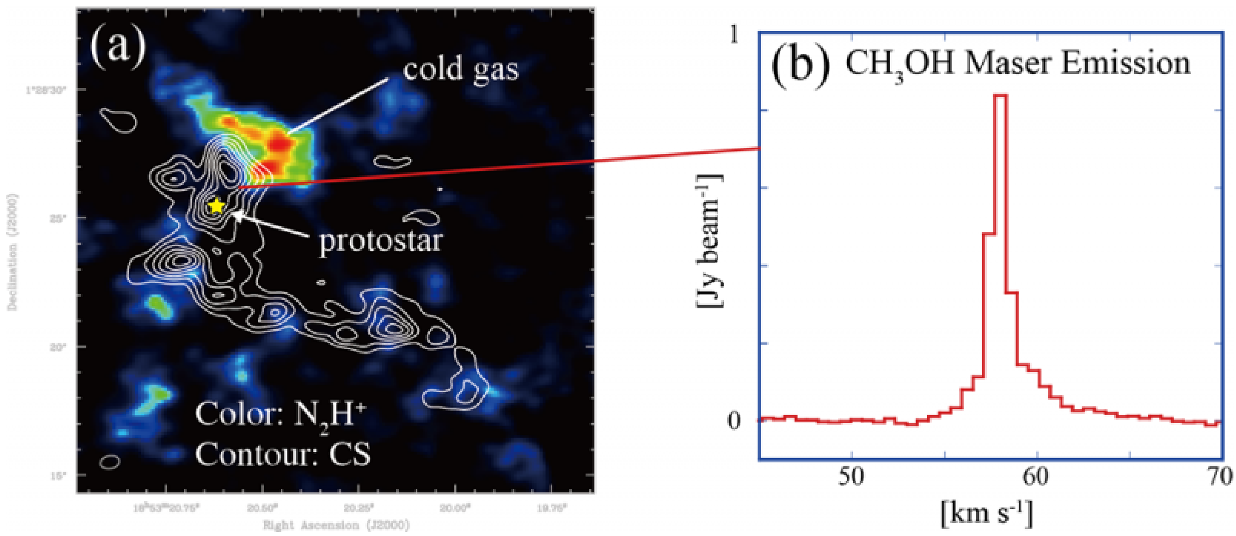
(a) 8 micron color image overlaid with 1.2 mm continuum (Rathborne et al. 2006). The blue circle indicates the observed object (G34.43+00.24 MM3). (b) CH_3OH color image overlaid with CS contour image taken with ALMA. The CH_3OH emission traces hot (>100 K) regions around the embedded protostar, while the CS emission traces the outflow driven by the protostar. (c) Artist's image.

In their experiments, Sakai uses the strategy of narrowing down possible targets using single dish telescopes such as those at the Nobeyama Radio Observatory (NRO) in Nagano Prefecture, Japan, and then use the 66 telescopes at ALMA for detailed analysis of these promising targets.

Needless to say astrophysics is a time consuming area of research, where it can take two to three years for data collection. "I collaborate with groups in other countries to write proposals for machine time on all the telescopes we want to use," says Sakai. "In the case of ALMA we usually get a few hours each year."

In research recent Sakai and an international team recently discovered a very young star of about 1000 years old [1,3] and observations of methanol masers in a molecular clump indicating the existence of a star-forming region [2].

"We hope this research will increase our knowledge of the formation of galaxies and ultimately shed light on the origin of life of Earth."



(a) N2H+ color image overlaid with CS contour image toward G34.43+00.24 MM3. The N2H+ emission traces cold gas, while the CS emission traces the outflow. The anti-correlation between N2H+ and CS suggests that the outflow is interacting with the cold dense gas. (b) Spectrum of methanol maser. We detected the methanol maser emission toward the interacting regions between the outflow and cold dense gas.

More information: [1] Takeshi Sakai et.al, ALMA OBSERVATIONS OF THE IRDC CLUMP G34.43+00.24 MM3: DNC/HNC RATIO, *Astrophysical Journal*, 803:70 (9pp), (2015)

[2] Takahiro Yanagida et.al, ALMA OBSERVATIONS OF THE IRDC CLUMP G34.43+00.24 MM3: 278 GHz CLASS I METHANOL MASERS, *Astrophysical Journal Letters*, 794:L10 (6pp), (2014).

[3] Takeshi Sakai et.al, ALMA OBSERVATIONS OF THE IRDC CLUMP G34.43+00.24 MM3: HOT CORE AND MOLECULAR OUTFLOWS, *Astrophysical Journal Letters*, 775:L31 (6pp), (2013)

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