High Mass Star Forming Regions in the Southern Hemisphere

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Abstract

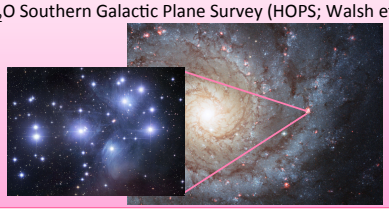
Almost all stars in our Galaxy are formed as members of stellar clusters, thus the understanding of cluster formation is one of the crucial issues in astronomy. We have studied 18 young massive clumps, observed radio waves coming from "dense molecular gas" surrounding embedded clusters with the Mopra 22m radio telescope. These observations are conducted in the Millimeter Astronomy Legacy Team Survey at 90 GHz (MALT90). From this survey, we have discovered that eight out of 18 objects are associated with *WISE* 4.6μm bubbles (*CWB: Clump with Bubbles*). The rest are not associated with 4.6μm bubbles (*CWOB: Clump without Bubbles*) and dark in the *WISE* 12μm images. Our results show that CWBs tend to have relatively large velocity widths, which might be related to their formation mechanism or might be effected by their environments. Moreover, our results give the hints to understand the formation mechanism of open clusters within our Galaxy. In the future, they will investigate the detailed structures of these objects with ALMA (Atacama Large Millimeter/submillimeter Array), which have 100 times the resolution.

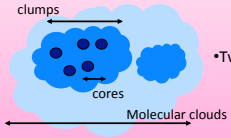
Dataset

Almost all stars (more than 90 % of stars within our galaxy), in particular massive stars (> 8 M_{sun}) within the disk of the Milky Way form as members of clusters (Lada & Lada 2003). Thus, clusters have been long considered as important laboratories for astronomy. In recent studies, the cluster-forming clumps, which are the dense regions in molecular clouds (size-1 pc, mass-100–1000M_{sun}, density-$10^{3\text{-}5}$cm^{-3}) are considered to be the parental objects of clusters (Lada & Lada 2003). We present the results of HCO^+(1-0) and N_2H^+(1-0) dataset from MALT90 towards H_2O Southern Galactic Plane Survey (HOPS; Walsh et al. 2008).

Mopra 22m telescope
- On The Fly (OTF)

Molecular lines
- HCO^+(1-0)
- N_2H^+(1-0)





•Hierarchy structure
–Molecular clouds (-10pc, $10^{2\text{-}3}$ cm^{-3})
–Clumps (-1pc, $10^{3\text{-}5}$cm^{-3})
–Cores (-0.1pc, $10^{5\text{-}6}$cm^{-3}) →stars
•Two modes of star formation
–Isolated star formation [-1M_{sun}]
–Taurus (Onishi et al. 1998)
–Cluster formation [low to high mass (>8M_{sun})]
–Orion (Ikeda et al. 2007)
–Most stars form in this mode

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1) N_2H^+(1-0) results

They are integrated intensity maps of N_2H^+(1-0) emission (contours) superposed on the *WISE* 4.6μm images for all HOPS targets. We can see bubble-like features in the left-side of images (*CWB: Clump with Bubbles*), and cannot see bubbles in the right-side of images (*CWOB: Clump without Bubbles*) .

CWBs

CWOBs

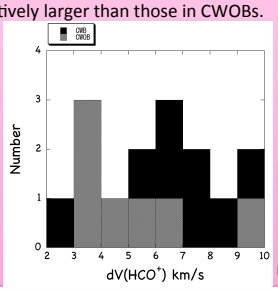
N_2H^+(1-0) maps (contour) vs. *WISE* 4.6 micron images for all HOPS targets

2) HCO^+(1-0) results

We derived the HCO^+ (1-0) line widths, ΔV_{obs} by fitting the HCO^+(1-0) spectra averaged over the clumps with a Gaussian function.
We found that velocity widths in CWBs are relatively larger than those in CWOBs.

Question?

Physical condition of the clumps seem to depend on the differences of the environments of the clumps. Some unknown issues of cluster formation (e.g., IMF, star formation efficiency, age spread of the cluster members) can be clarified by carrying out an investigation of the clumps with different environments.

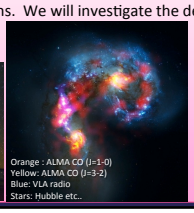


N_2H^+(1-0) maps (contour) vs. *WISE* 12μm images for CWOBs

Histograms of the velocity widths between CWBs and CWOBs.

ALMA (Atacama Large Millimeter/submillimeter Array)

ALMA is a gigantic radio interferometer array with 66 parabola antennas. ALMA consists of fifty 12m antennas and "Atacama Compact Array (ACA)" which is composed of four 12m antennas and twelve 7m antennas. By spreading these transportable antennas over the distance of up to 18.5 km, ALMA achieves the resolution equivalent to a telescope of 18.5 km in diameter, as a telescope with the world's highest sensitivities and resolutions at millimeter and submillimeter wavelengths. We will investigate the detailed structures of dense clumps with ALMA, which have 100 times the resolution soon!



M100 CO(1-0) combination images →
Left: Integrated intensity map
Right: Velocity fields map
Cycle 1 observations allow combination between interferometric and single dish dataset.
Credit: ALMA (ESO/NAOJ/NRAO)

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The Antennae Galaxies is a pair of colliding galaxies with dramatically distorted shapes. While visible light shows us the stars in the galaxies, ALMA's view reveals something that cannot be seen in visible light: the clouds of dense cold gas from which new stars form . This is the best submillimeter-wavelength image ever made of the Antennae Galaxies.
Credit: ALMA (ESO/NAOJ/NRAO)