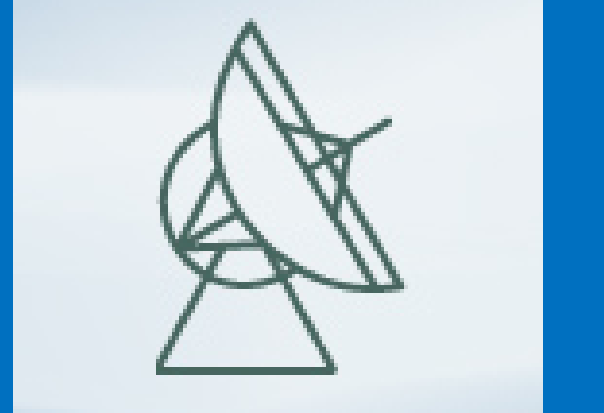


Triggered Star Formation at the End of the Galactic Bar?



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Abstract The interstellar bubble N36 created by an HII region and surrounded by a swept-up layer is an exceptional target to study triggered massive star formation. Combining infrared and radio data, N36 turns out to be a vigorous star forming region at a location where the Norma Galactic arm meets the Galactic bar. This makes it possible to investigate in spatial detail conditions of a molecular cloud affected by the presence of a large scale bar.

Data used in this study

data	Telescope	Survey
$^{12}\text{CO}/^{13}\text{CO}/\text{C}^{18}\text{O}$	PMO-13.7m	MWISP ¹
3.6 μm /8 μm /24 μm	Spitzer	GLIMPSE& MIPS GAL
70 μm /160 μm /250 μm	Herschel	Hi GAL
870 μm	APEX	ATLAS GAL
HI/20 cm continuum	VLA	VGPS

(1) The Milky Way Imaging Scroll Painting (MWISP) project conducts a galactic plane survey in three main CO isotopologues.

The Location of N36 in the Milky Way

N36 is selected from the sample of Gong et al. (2012). Using the Galactic rotation curve of Reid et al. (2009) and the Gaussian fit velocity of the average ^{13}CO (1-0) emission ($V_{\text{lsr}}=107.2 \text{ km s}^{-1}$), we calculated for N36 a near distance of 5.7 kpc and a far distance of 9.6 kpc. The HI absorption correlates well with ^{13}CO emission, which clearly favors the near distance. Thus, N36 is located at the place where the Norma Galactic arm meets the Galactic bar (See Fig.1).

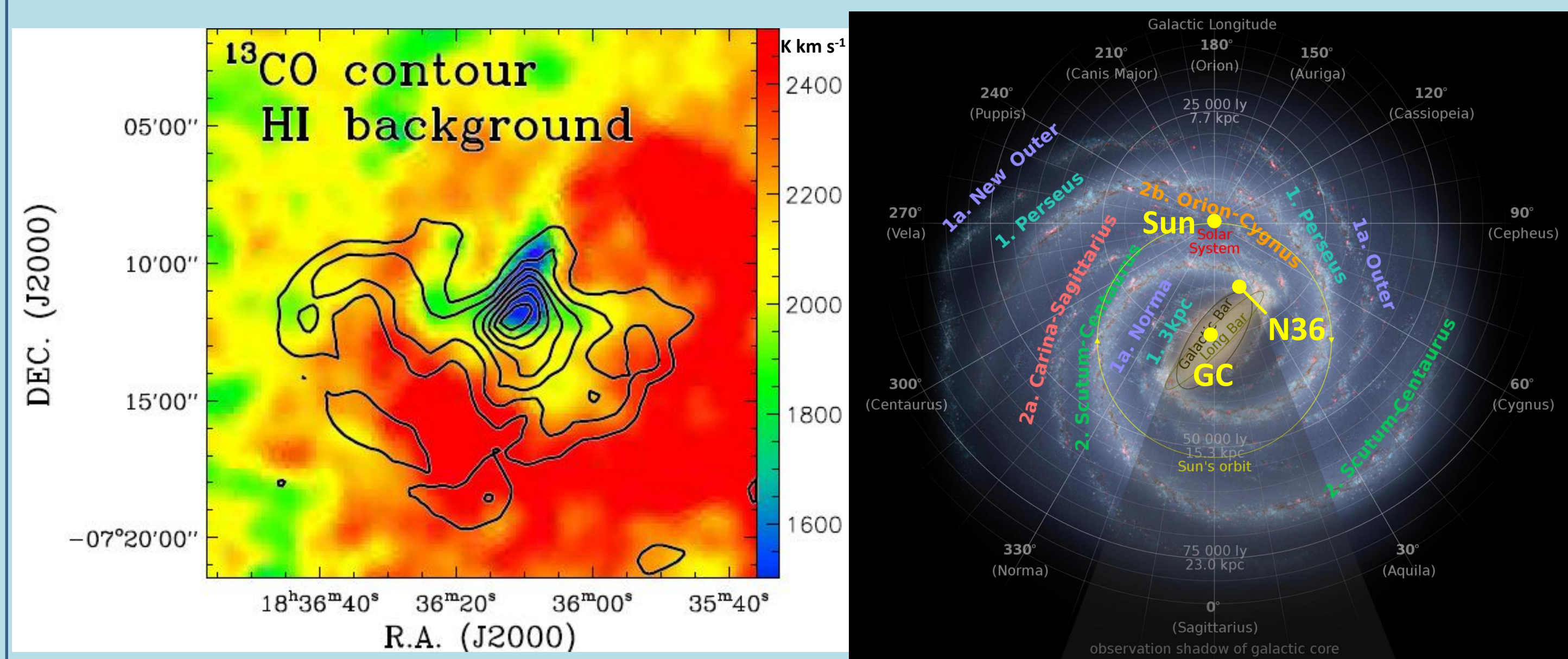


Fig.1 Left: ^{13}CO (1-0) integrated intensity map (contours) overlaid on the HI integrated intensity image of the N36 region. Right: Artist view of the Galaxy seen face-on with N36, Sun and the Galactic Center (GC) indicated by yellow circles.

The interaction between HII regions with ambient clouds

Arc-like structure is found in the p-v diagram. It indicates that the bubble is possibly expanding, which is likely to result from the energy input of the HII regions such as the expansion of HII regions and stellar winds of massive stars.

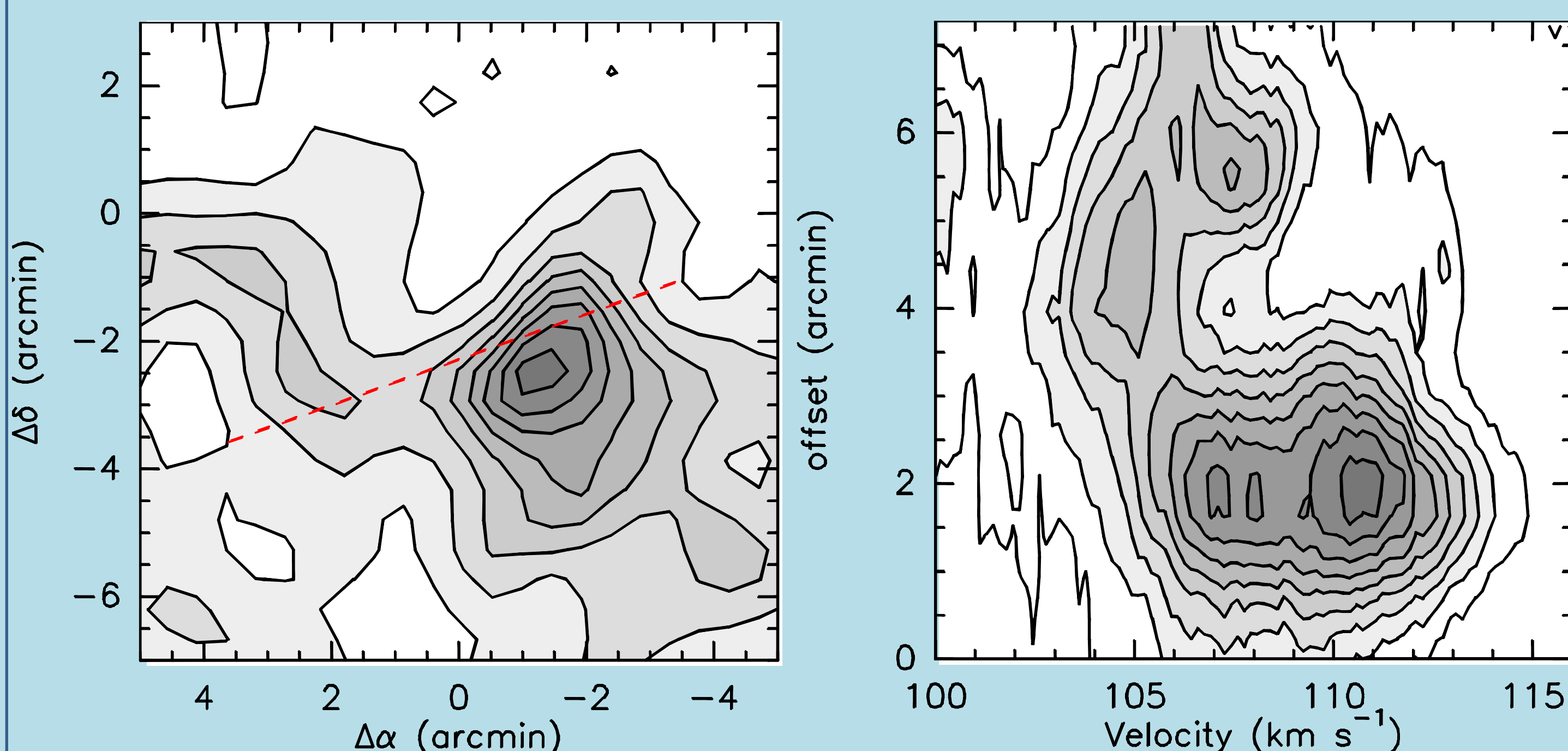


Fig. 2 Left: ^{13}CO (1-0) intensity map integrated from 100 to 115 km s^{-1} . The red dash line is the p-v cut line. Right: ^{13}CO (1-0) p-v map along the red dash lines in the left panel. The offset 0 is corresponding to (-3.5, -1) in the left panel. The arc structure is a clue that the HII region may interact with its ambient clouds.

A collision of different flows?

Observational studies have found evidence of a Galactic bar that has a radius of 4.4 kpc and is oriented about 44° relative to the Sun-Galactic center line of sight (Benjamin et al. 2005). The Galactic bar is the place where the circular orbit transits to elliptical orbit. Due to its potentials, cloud-cloud collisions may happen in the region.

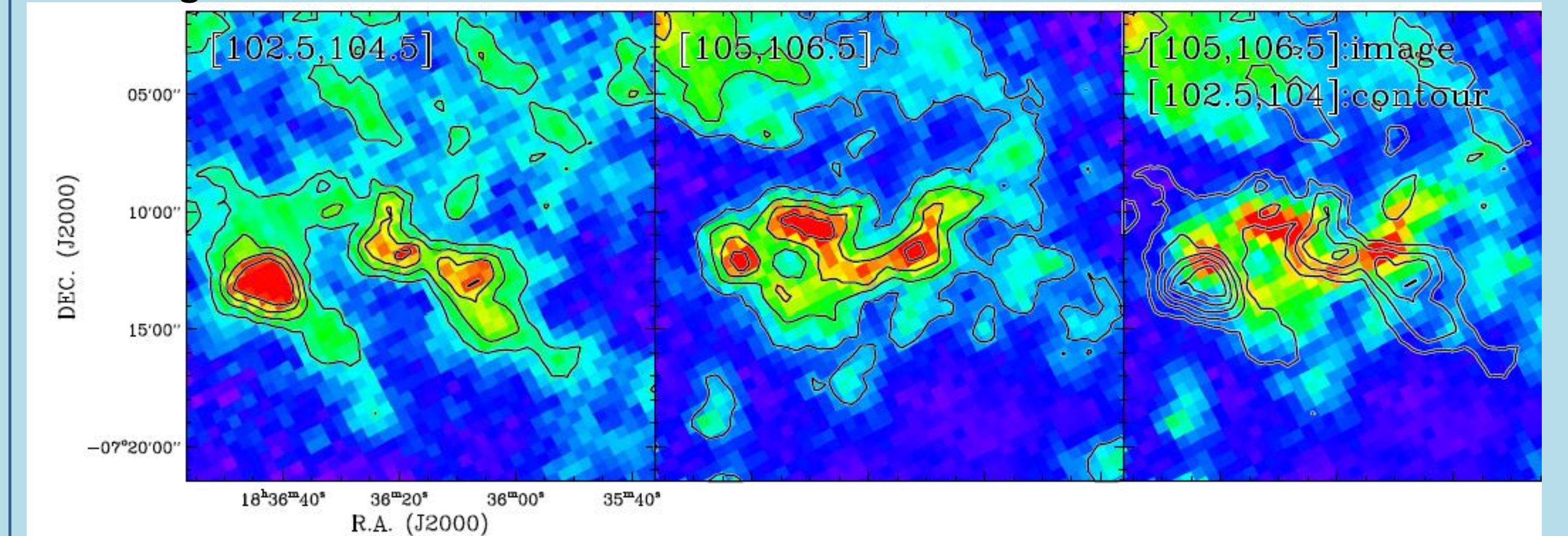


Fig.3: Different flows may collide due to bar potentials. Shown are the integrated ^{13}CO (1-0) maps for two possible different flows whose velocity ranges are given in the upper left of each panel. For the right panel, two possible flows are shown in image and contours, respectively.

Triggered star formation toward N36?

We found that an swept up layer surrounding the HII regions, and the layer is able to collapse. Furthermore, we found several signposts of massive star formation around N36. They suggest that triggered star formation may happen near the bubble.

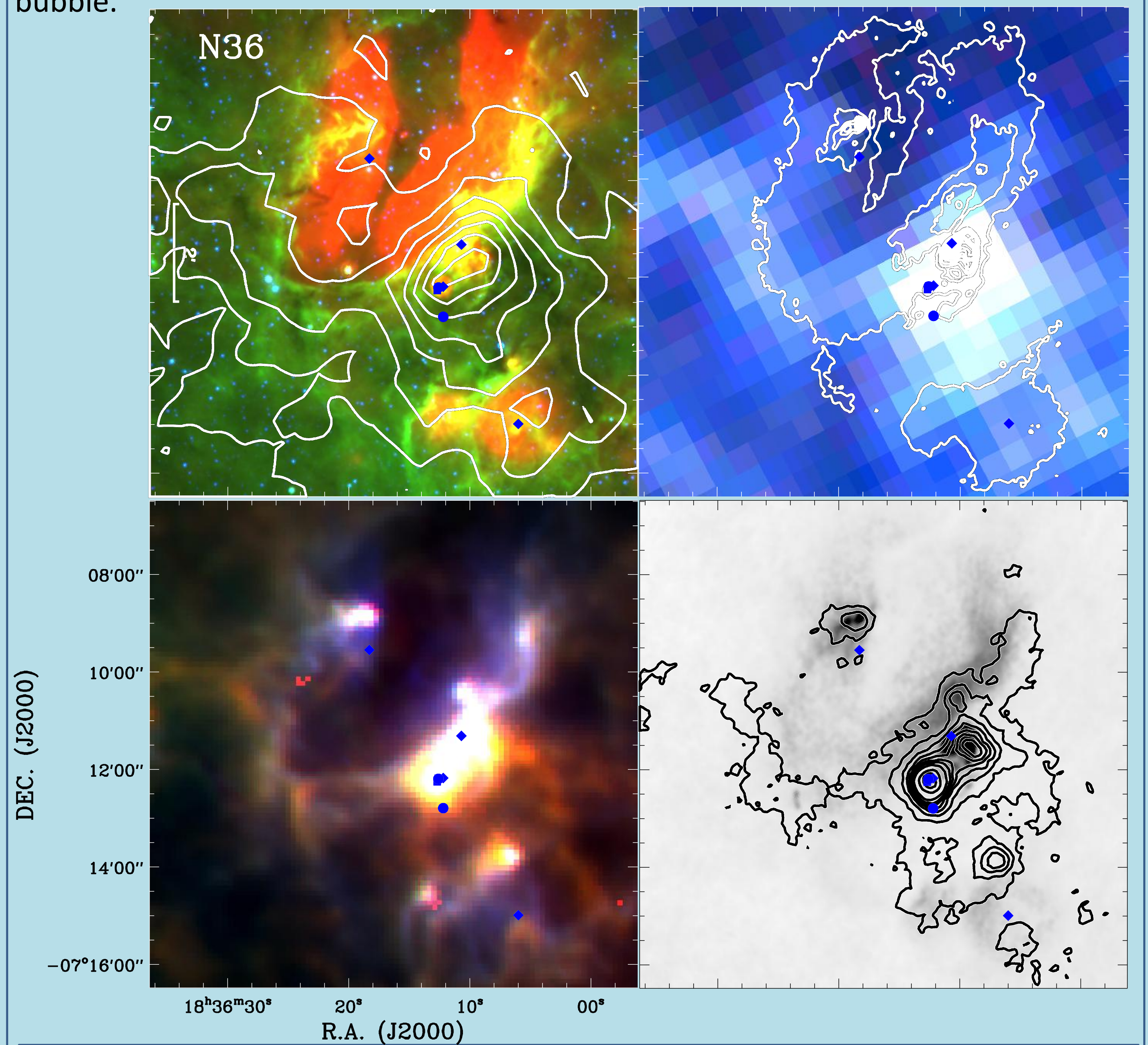


Fig.4 Top left: Three color Spitzer images (3.6 μm : blue, 8.0 μm : green, 24 μm : red) overlaid with MWISP C^{18}O (1-0) integrated intensity contours (white). Blue circles, squares and diamonds stand for methanol masers, UCHII regions and MYSOs, respectively. The vertical scale bar represents $2'$. Top right: Three color MWISP images (^{12}CO : blue, ^{13}CO : green, C^{18}O : red) overlaid with 20 cm continuum contours (white). Bottom left: Three color images (70 μm : blue, 160 μm : green, 250 μm : red) from Herschel. Bottom right: VGPS 20 cm continuum emission overlaid with ATLASGAL-870 μm continuum contours (black).

Future work

- to search for more evidence of the interaction between HII regions and ambient clouds. If the natal cloud is affected by the centralized pressure, the denser portions of the bubble would be moving slower so a velocity difference is possibly found with different density tracers if observed with high resolution.
- to check if cloud-cloud collisions happen in this region.

Reference:

Benjamin, R. A., Churchwell, E., Babler, B. L., et al. 2005, *AJ*, 630, L149
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 Reid, M. J., Menten, K. M., Zheng, X. W., et al. 2009, *AJ*, 700, 137