An Atomic Carbon View of Massive Star Formation

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The source

We present the first result of the atomic carbon (CI, $^3P_1$ – $^3P_0$) mapping of the massive star forming region G333.6-0.2, part of our CI mapping of giant molecular clouds Vela C and G333 project. The project aims to investigate the mass distribution among a wide range of enviroments, the impact of star formation and the energy cascade in the GMC, utilising CI and multiple molecular species. Our first mapped region G333.6-0.2 has an HII region with an embedded OB star cluster, and within its proximity a molecular source associated with a MSX source and 1.2 mm dust core, along with H_2O and OH masers (Figure 1). The mm core has a dust mass of 3300 $M_\odot$ and density of 3 x 10^7 cm^{-3}. 3D radiative transfer modelling with MOLLIE of six different molecular line molecular line maps (^{12}CO, ^{13}CO, $C^{18}O$, CS, HCO^+ and $H^{13}CO^+$) shows that the molecular source has high infall velocity (13 km s^{-1}) and rate (0.01 $M_\odot$ yr^{-1}), outflows (0.006 $M_\odot$ yr^{-1}), and supersonic turbulence (3.5 km s^{-1}), suggesting this is a scaled-up version of low mass star formation (*Lo et al. 2013, sub*).

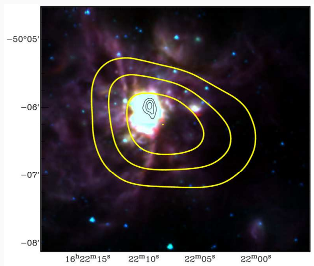

Figure 1: CS (yellow contours) emission and 4.8 Ghz continuum (black contours) overlaid on GLIMPSE 3-colour (3.6, 4.8, 8.0μm) composite image, giving an overview of the G333.6-0.2 high mass star forming region (*Lo et al. 2013, sub*).

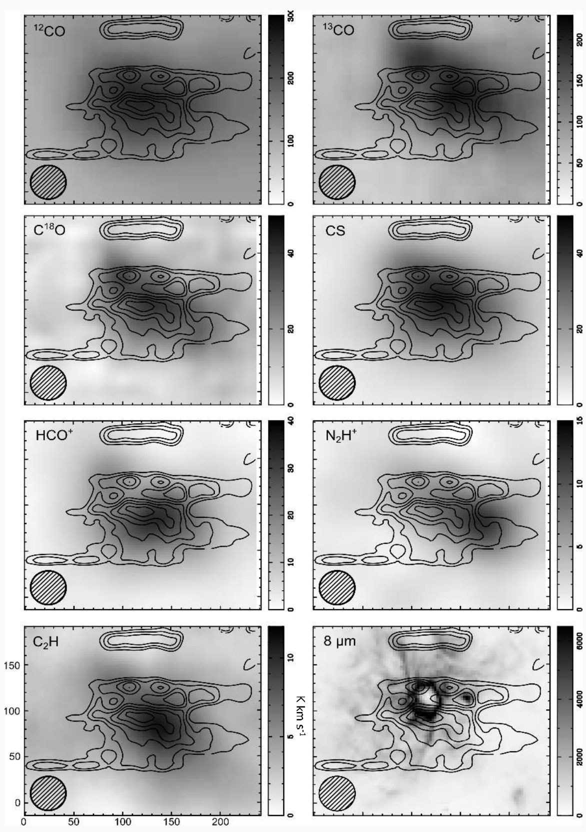

Figure 2: CI emission (contours) overlaid on molecular line maps of ^{12}CO, ^{13}CO, $C^{18}O$, CS, HCO^+, N_2H^+ and C_2H, and GLIMPSE 8 μm image of G333.6-0.2. Contour levels of CI start at 50 K km s^{-1} with increments of 10 K km s^{-1} (*Lo et al. 2013, prep*).

CI mapping

The CI emission at 496 GHz was observed with the Nanten2 telescope at 4865 m altitude at Pampa la Bola in the Atacama desert, Chile. Show in Figure 2 is the CI map (contours) overlaid on a collection of integrated molecular emission maps and GLIMPSE 8 μm image. The CI emission is fairly extended spatially, it exibits a strong correlation with ^{12}CO and CS, while other molecular species show differences in spatial distribution. Among them N_2H^+ has the largest offset, ~1' west of the CI peak, it also has a relatively compact emission compare to other molecules, as expected for being a cold dense gas tracer. Figure 3 are the line profiles of CI and other molecular emissions as shown in Figure 2. The CO isotopologues and CI have the highest line widths (8 – 10 km s^{-1}), while the other molecules has line width of 5 – 7 km s^{-1}. From the Gaussian fit of the line profile, CI intensity is twice of $C^{18}O$ but three times weaker than ^{12}CO, the CI/^{13}CO ratio is of 0.42 and 0.37 for CI/^{12}CO. The CI/^{12}CO and CI/^{13}CO intensity ratio maps are shown in Figure 4, showing the notable variance across the region.

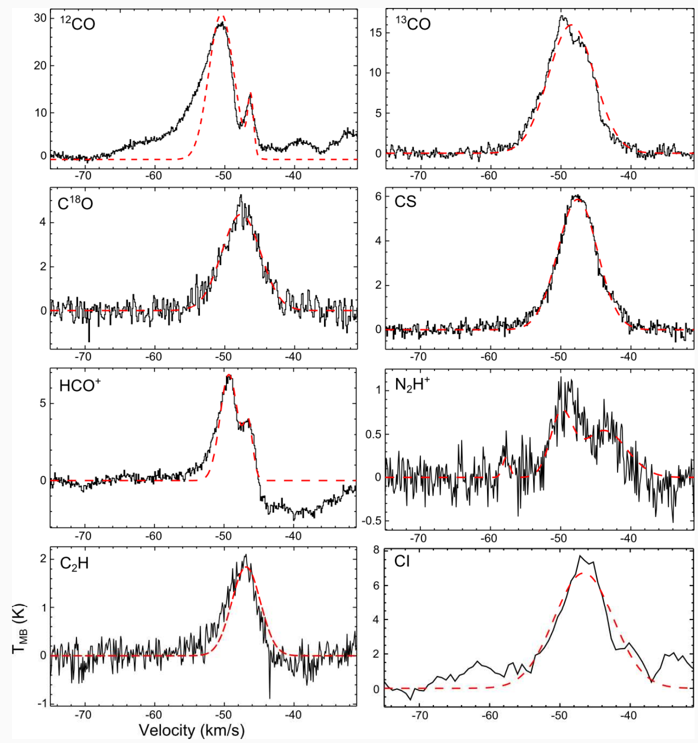

Figure 3: Spectra profiles of various molecules at the peak position of CI emission. The red dashed lines are Gaussian fits to the line profiles (*Lo et al. 2013, prep*).

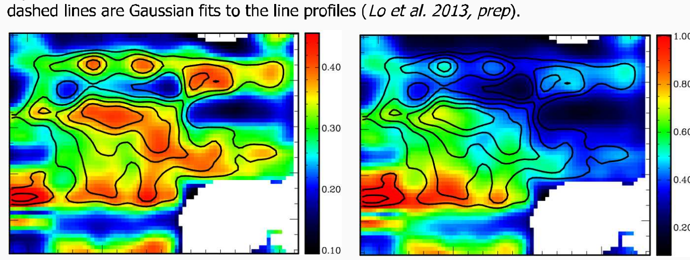

Figure 4: Intensity ratio map of CI/^{12}CO (left) and CI/^{13}CO (right), overlaid with black contours of CI integrated emission (*Lo et al. 2013, prep*).

We have shown our latest addition of CI to the multi-molecular line mappings of GMCs, along with upcoming observations of CII we aim to provide a comprehensive study of energy transfer, mass distributions of star formation in GMCs.

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