CLASSy: Continuum and Gas Structures in the Serpens Main, Perseus B1, & NGC 1333 Star Forming Regions

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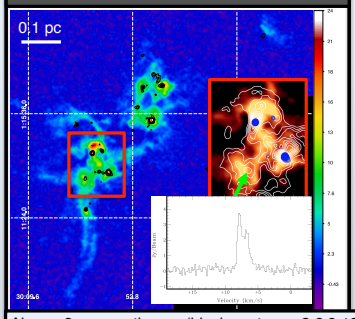
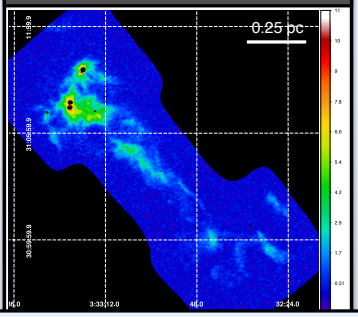
ABSTRACT

We present CARMA Large Area Star formation Survey (CLASSy) continuum and gas structures, a comparison with known protostellar sources, and velocity maps in the Serpens Main, Perseus Barnard 1 (B1), and NGC 1333 regions. The main goal of CLASSy is to study the star formation process from large to small scales by utilizing CARMA-23 and single-dish modes. Serpens Main is a nearby region (415 pc) of active low- to intermediate-mass clustered star formation. NGC 1333 lies at a closer distance of 235 pc and is a highly active star forming region. B1 is located 3.5 pc to the east of NGC 1333, and is thought to be in an earlier stage of evolution. We compare the distribution of CLASSy 3 mm continuum sources with Spitzer YSOs and Herschel 160 μm emission. We also present the gas structures traced by N_2H^+(1-0) and compare to the distribution of continuum sources. Where continuum sources have associated N_2H^+ peaks or Spitzer YSOs, the separation between the components is < 4 arcsec in ~2/3 of the sources. The kinematic information from our spectral line cubes facilitates a deeper understanding of how the continuum sources may have formed, and how they may be currently impacting the dense gas.

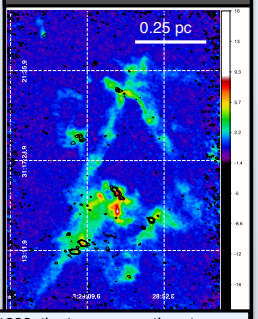
SERPENS MAIN



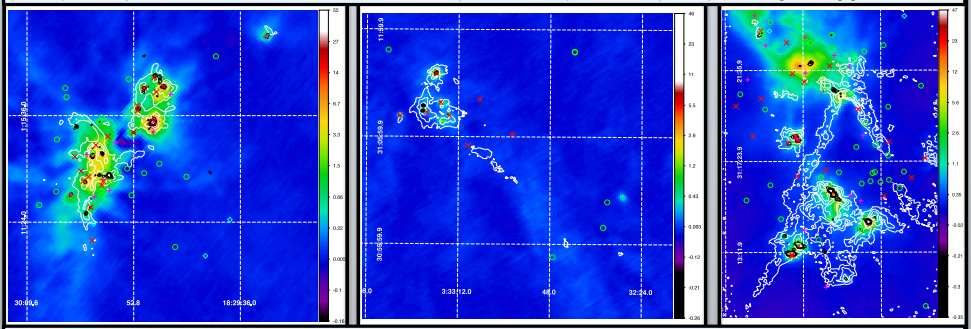
B1



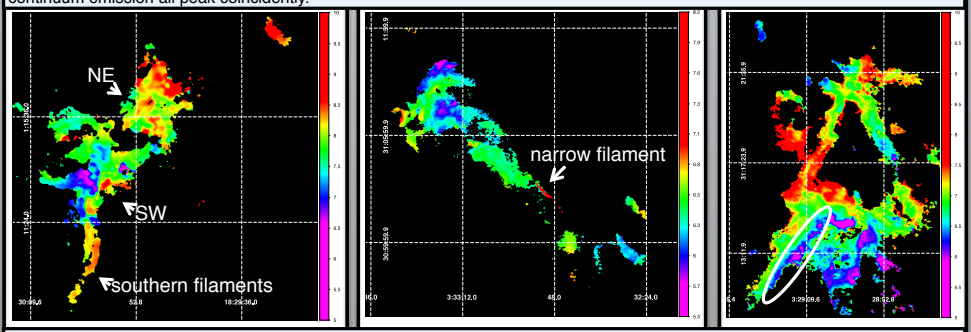
NGC 1333



Above: 3 mm continuum (black contours: 3,6,9,12σ) and N_2H^+ (color map). Serpens Main and NGC 1333, the two more active star-forming regions, each have ~20 continuum sources while B1 has ~3. The continuum sources tend to be embedded within N_2H^+ emission, and many sources have associated peaks in N_2H^+. See top-right for analysis of continuum and N_2H^+ peak separations. The inset Serpens Main images show: (top) N_2H^+ emission (color scale) overlaid with white (HCN) and blue (3 mm continuum) contours, (bottom) HCO^+ spectrum towards the center of a molecular clump with an absorption feature possibly indicating infalling gas motion.



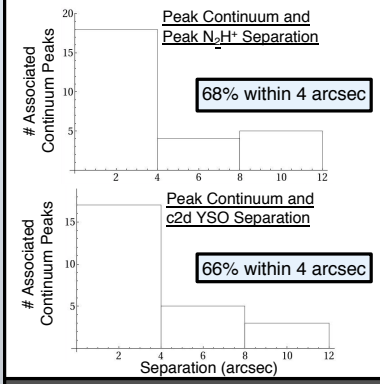
Above: 3 mm continuum (black contours), N_2H^+ (white contours), Herschel 160 μm (color map), c2d Survey[a] YSOs (Class I—X, Class F—+, Class II—O, Class III—◇)[b]. Class I and F appear to be mostly coincident with gas, however, Class II and III appear to have less correlation with gas. See top-right for analysis of continuum and YSO separations. N_2H^+, Herschel 160 μm, and continuum emission all peak coincidently.



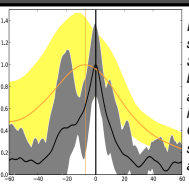
Above: N_2H^+ 1st moment (velocity) maps. In Serpens Main, the NW subcluster has higher velocities than the SE subcluster, and the velocities of the southern filaments are higher compared to the SE subcluster. The complex, overlapping filamentary structures, in combination with the identified continuum cores, provide a great testbed for understanding filament formation and fragmentation in clustered star forming regions. In B1, a very narrow filament is revealed to be offset by 1.5 km/s from the bulk gas emission, raising the question of how it was formed. We also see that the B1 tail is less turbulent that the main core, which correlates well with finding more active protostars and dense continuum sources within the main core. In NGC 1333, there is a low velocity structure (circled) parallel to a higher velocity filament, also present in linewidth maps, indicating a possible turbulent collision. This type of collision may have seeded over-densities that led to the formation of the IRAS 4 continuum complex, which lies along that ridge.

CONTINUUM PEAK, N_2H^+ PEAK, & YSO CORRELATION

Below: Histograms of separation between peak continuum, peak N_2H^+, and c2d YSOs. Across all regions, 27 continuum peaks had associated N_2H^+ peaks, and 25 had associated c2d YSOs (of which only 4 were Class II or III).



FILAMENT INTENSITY PROFILE IN SERPENS MAIN



Intensity profiles for two southern filaments in Serpens Main as measured by Herschel (yellow shaded area, orange line for average intensity) and by N_2H^+(1-0) CARMA observations (grey shaded area, black line for average intensity).

We are characterizing the morphology of filaments seen in N_2H^+, and determined the width of the two southern filaments with intensity-position cuts perpendicular to the filaments at several positions along their length. The width of each one is 0.03 and 0.02 pc. The same structure is regarded as one single filament by Herschel with a 0.13 pc deconvolved average width.

IMPORTANT POINTS

- We presented 3 mm continuum detections in completed CLASSy regions in relation to the dense gas, dust, and protostellar content.
- While not all continuum sources have c2d Survey[a] counterparts, those that do are associated with YSOs of younger classes, and ~2/3 are within 4 arcsec in separation.
- Where continuum peaks are associated with N_2H^+, again ~2/3 are within 4 arcsec in separation.
- CLASSy velocity maps are key to probing questions of turbulent fragmentation and core/filament formation. We are resolving filament widths as narrow as 0.02 pc.

GRANT
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REFERENCES
[a] Evans et al. 2009 ApJs 181 321; [b] Greene et al. 2004 ApJ 434 614

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