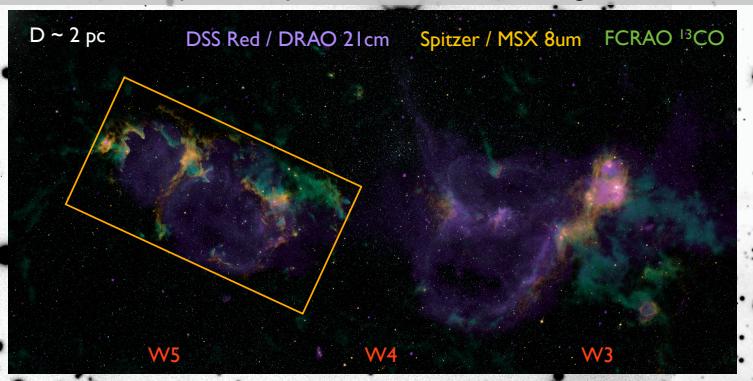
Star Formation in the Perseus Arm

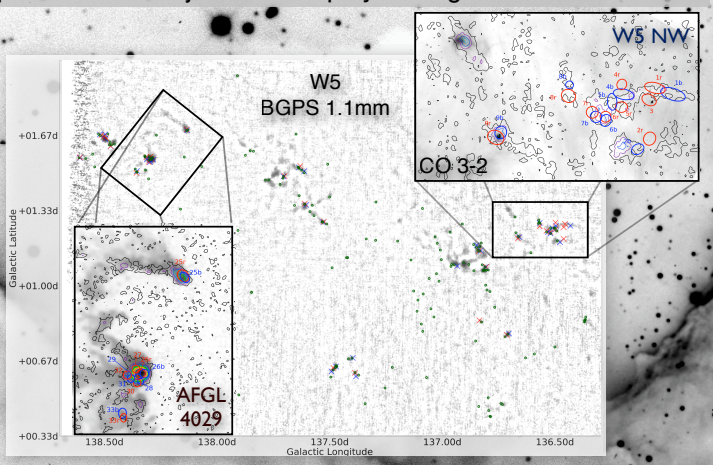
Adam Ginsburg, John Bally (University of Colorado, adam.ginsburg@colorado.edu)
Jonathan Williams (University of Hawaii), Christ Brunt (University of Exeter)

We present James Clerk Maxwell Telescope HARP CO 3-2 and Caltech Submillimeter Observatory Bolocam Galactic Plane Survey 1.1mm continuum observations of the W5 and L111 star forming complexes.

The W5 complex is part of the W3/4/5 group around ℓ=135. It is often cited as an example of triggered star formation (Lefloch et al. 1997; Thompson et al. 2004; Karr & Martin 2003). Koenig et al. (2008) used Spitzer colors to identify class I-III objects in the complex, but our data reveals outflows in locations previously not known to be forming stars.



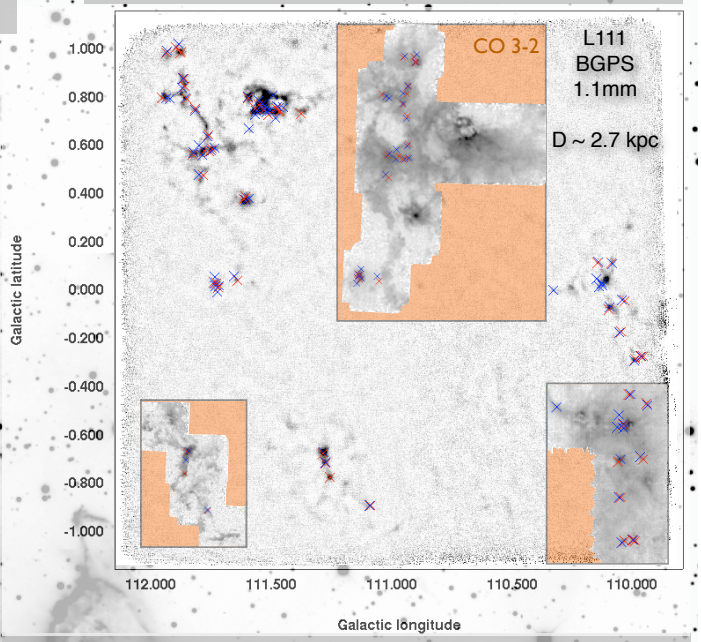
We have found 38 outflow candidates in W5 using HARP CO 3-2 data. The outflows are shown overlaid as X's on the BGPS 1.1mm image. Spitzer Class I objects are displayed as green circles.



The northwest section of W5 shows the most outflow activity. While abundant ^{13}CO is evident (top image), the region is IR-faint (in IRAS bands) and is relatively faint at 1.1 mm, and it was therefore not previously suspected of forming stars.

The cometary clouds in W5 all show outflow activity and all cometary clouds with a size near the resolution of the BGPS (~33") are mm-bright.

The L111 complex contains the massive protostar cluster NGC 7538 and Sharpless HII regions 156-159. There is no clear case for triggering, though all of the star formation is near HII regions.



We have found ~50 outflow candidates in L111. While the prominent and well-known NGC 7538 sources are well-studied, the surrounding regions have only recently been recognized as star-forming.

- ➡Most BGPS sources are associated with outflows: 1.1mm emission is an excellent tracer of ongoing star formation
  - ➡Most outflows are associated with BGPS sources
- ➡1.1mm sources in both W5, an example of triggering, and L111, where there is no clear case for triggering, are star-forming
- ➡The gas far from and unaffected by the O-stars in W5 shows signs of active star formation

On 10 parsec scales, local triggering is not responsible for all star formation.

Our survey extends to other wavelengths - Hα, [S II], H_2 in the optical and near-IR - and we have made use of archival IRAS and CGPS 21cm data to identify and analyze interesting individual objects. In addition, we have used the NIR and optical spectrographs on the Apache Point Observatory to confirm many outflow candidates.

References:
Aguirre et al 2010, ApJS, submitted
Koenig, X. et al 2008, ApJ, 688, 1142
Lefloch, B. et al. 1997, A&A, 324, 249
Rosolowsky et al 2010, ApJ, accepted
Thompson, M. A. et a. 2004, A&A, 414, 1017

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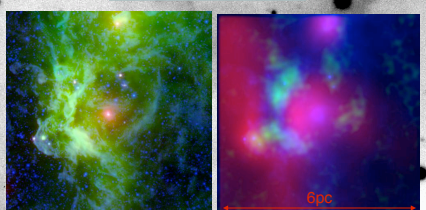
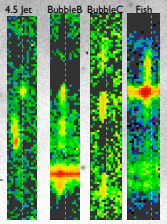


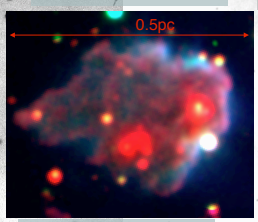
H_2 / 8μm / 24μm

24μm / 1.1 mm / 21 cm



H_2 PV diagrams

"The Fish"
IRAS 02497+6018



Hα / [S II] / H_2

A bubble around NGC 7538 is seen at many wavelengths

CO 3-2 | 24μm | 8μm | 1.1mm / 20cm