Reionization to Exoplanets: Spitzer's Growing Legacy
*ASP Conference Series, Vol. **VOL**, © 2010*
P. Ogle, ed.

The *Spitzer* Legacy Survey of the Cygnus-X Region

Joseph L. Hora[1], R. A. Gutermuth[2,3], S. Carey[4], D. Mizuno[5], K. E. Kraemer[6], X. P. Koenig[1], S. Bontemps[7], S. T. Megeath[8], N. Schneider[9], F. Motte[9], E. Keto[1], H. A. Smith[1], L. E. Allen[1,10], R. Simon[11], S. Price[6], J. D. Adams[12], G. G. Fazio[1]

[1]*Center for Astrophysics, 60 Garden St., MS 65, Cambridge, MA 02138,*
[2]*Smith College, Northampton, MA, USA,*
[3]*Dept. of Astronomy, University of Massachusetts, Amherst, MA, USA,*
[4]*Spitzer Science Center, Pasadena, CA, USA,*
[5]*Institute for Scientific Research, Boston College, Boston, MA, USA,*
[6]*Air Force Research Laboratory, Hanscom AFB, MA, USA,*
[7]*Observatoire de Bordeaux, BP 89, 33270 Floirac, France,*
[8]*Dept. of Physics and Astronomy, University of Toledo, Toledo, OH, USA,*
[9]*AIM/SAp, CEA-Saclay, 91191 Gif Sur Yvette Cedex, France,*
[10]*NOAO, 950 North Cherry Avenue, Tucson, AZ, USA,*
[11]*I. Physik. Institut, Universität zu Köln, 50937 Köln, Germany,*
[12]*Cornell University, Dept. of Radiophysics Space Research, Ithaca, NY, USA*

Abstract. We describe the first data delivery from the *Spitzer* Legacy Survey of the Cygnus-X region, which is a massive star formation complex containing the richest known concentration of intermediate mass to high mass protostars and the largest OB association within 2 kpc. This unbiased survey of 24 square degrees in Cygnus-X with the *Spitzer* IRAC and MIPS instruments has the sensitivity to detect young stars to a limit of 0.5 $M_{\odot}$. The data release consists of a source catalog and mosaics of the images in each band that combine all of the frames obtained in the various observation epochs. The source catalog contains the band-merged *Spitzer* 3.6, 4.5, 5.8, 8.0, and 24 μm photometry as well as the 2MASS *J, H,* and *Ks* bands. A preliminary source classification using this data set has yielded over 2000 deeply embedded and Class I YSO candidates, and over 12000 Class II candidate objects. By extending the sample of star forming clouds and complexes surveyed by *Spitzer* during the cryo-mission to the most active star forming complex within 2 kpc, the Cygnus-X survey has made an essential contribution to Spitzer's legacy of characterizing star formation in our Galactic neighborhood.

1 Mosaics and the Point Source Catalog

The survey used the *Spitzer* IRAC (Fazio et al. 2004) and MIPS (Rieke et al. 2004) instruments to survey ∼24 square degrees in the Cygnus-X region. The IRAC observations were obtained using 12s High Dynamic Range mode. All frames were combined into mosaics with WCSmosaic (Gutermuth et al. 2008). such that rotation, spatial scale distortion, and subpixel offset resampling are all performed in one transformation, to minimize smoothing. Automated source detection and aperture photometry were performed using PhotVis version 1.10 (Gutermuth et al. 2008), using the standard IRAC calibration (Reach et al.

2005). The MIPS data was reduced using the same techniques as in the MIPS-GAL Legacy program (Mizuno et al. 2008; Carey et al. 2009). The MIPSGAL pipeline performs many of the same operations as the standard SSC pipeline, but it has several modifications appropriate for bright, saturation- filled regions of the sky, and an improved droop correction and mitigation of other artifacts such as "jailbar" and latent images.

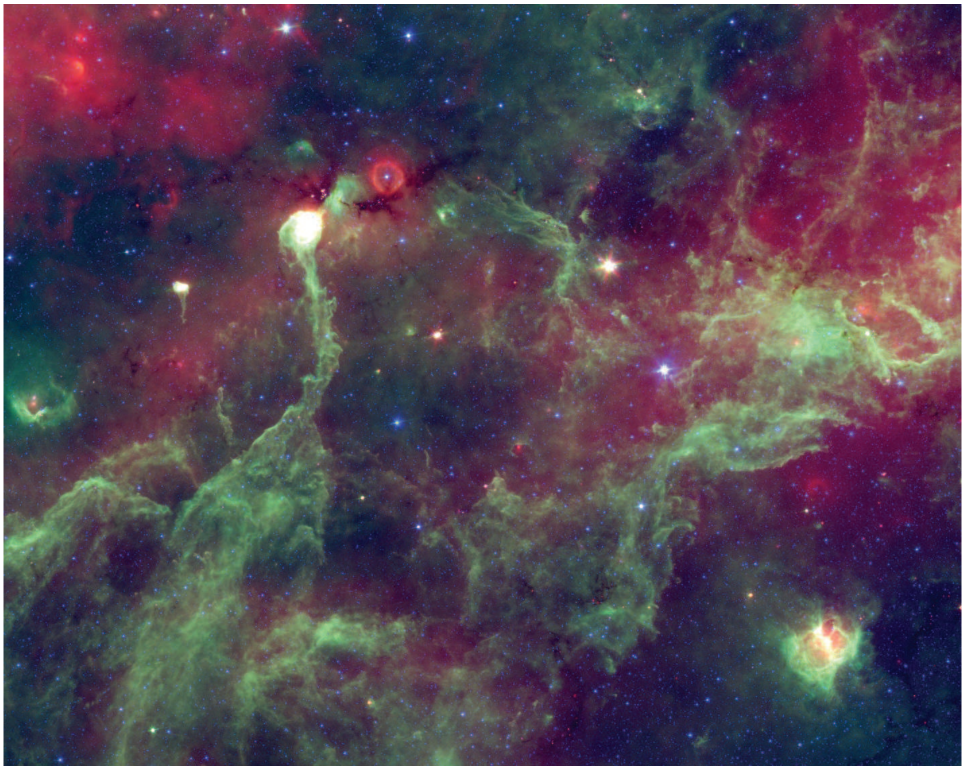

Figure 1. The central region of the Cygnus-X survey, with the 3.6 μm image as blue, 8.0 μm as green, and 24 μm as red. The image is approximately 1.85×1.4 degrees in size, centered near 20:30:55, +39:58:00 (J2000), south of the OB association Cyg OB2. The brightest region is at the top of the pillar in the upper left region, which is IRAS20306+4005. Just NW of that source, the red shell around the bright star is the LBV candidate G79.29+0.46. At the extreme left center of the image is DR15. The bright H II region in the lower right corner is DR6. Just above it in the right center of the image is AFGL 2591.

Classification of sources is performed using the multi-phase mid-IR colors method explained and justified in detail in Gutermuth et al. (2008), but updated to account for complications found in the more active, luminous and distant regions of the survey (Gutermuth et al. 2009). In summary, the method uses the numerous available flux ratios, or colors, to identify and classify YSOs as robustly as possible while mitigating the effects of contamination and reddening. Contamination arises from sources with excess IR emission, including star-forming galaxies, broad-line active galactic nuclei, and unresolved shock emission from outflows. The YSOs are classified into the canonical categories of Class I (protostars with infalling envelopes, including flat spectrum objects) and Class II (pre-main sequence stars with optically thick disks) YSOs (Allen et al. 2004), with supplemental categories of deeply embedded sources and the transitional disks. There are approximately 3.6 million sources in the full catalog of 2MASS/IRAC/MIPS sources. Our preliminary analysis yielded 1143 deeply embedded sources, 1627 Class I, 12445 Class II, 901 transition disks, 2340 AGN, 1498 PAH-dominated, and 22 H_2 knots.

2 Distribution of YSOs

The spatial distribution of the candidate Class I and Class II sources are shown in Figure 2, plotted on the 3.6 μm image of the Cygnus-X region. The strongest concentration of Class I sources are along filaments and in the densest parts of star-forming regions. The Class II objects are also clustered around the filaments and H II regions, but are not as tightly grouped as the Class I sources. In addition to clusters associated with DR21/22, W75 and AFGL 2591, there is a very large cluster of primarily more evolved Class II sources coincident with Cyg OB2.

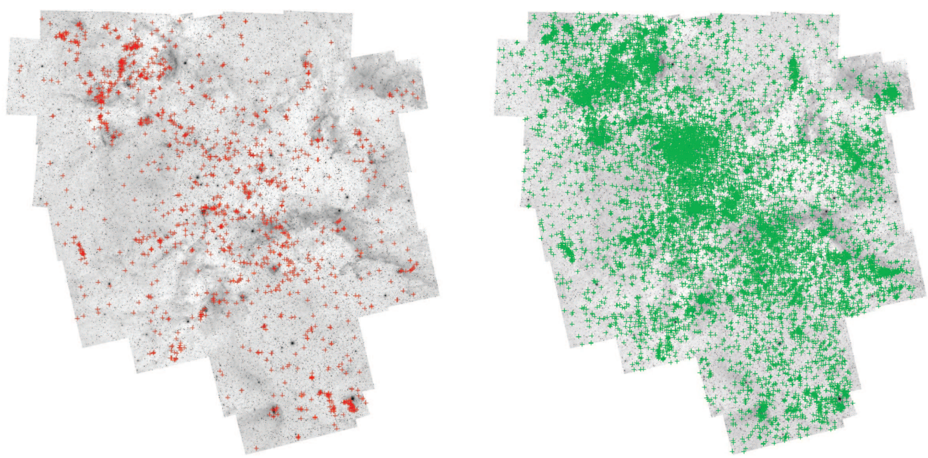

Figure 2. Left: Location of sources identified as Class I candidates (red crosses) overlayed on the 3.6 μm image. Right: Sources identified as Class II candidates (green crosses) plotted on the 3.6 μm image.

We plot the distribution of infrared excess sources in Figure 3, color-coding the objects according to an estimate of their local volume density. The volume density is calculated in the following way. We take the list of objects classified as YSOs (Class I, II, 'Deeply Embedded' Protostars and Transition Disks) from the full IRAC/MIPS Cygnus-X catalog. For each object in this list we derive d_6: the distance to the 6th nearest neighbor (following Castertano & Hut (1985) in choosing the sixth nearest neighbor distance). We assume an average mass of 0.5 $M_\odot$ and convert to a volume density, which is plotted for each object with the color scale shown in the Figure. The highest densities are in the regions listed above, and near IRAS 20306+4005.

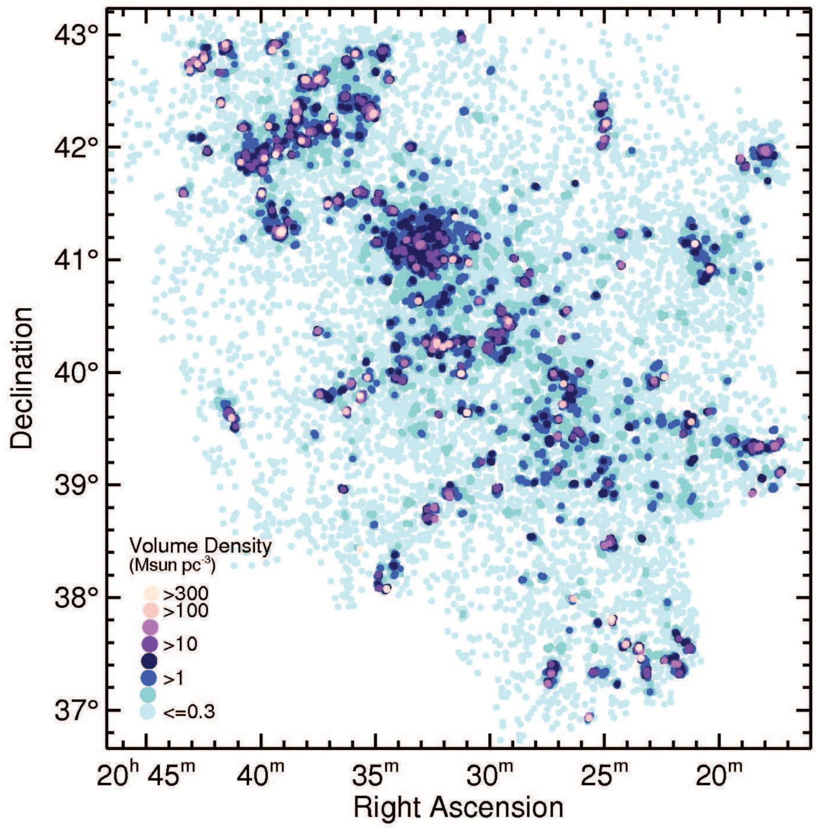

Figure 3. The space density of of all objects classified as YSO candidates, from ≤ 0.3 to >300 parsec^{-3}.

Acknowledgments. This work is in part based on observations made with the *Spitzer* Space Telescope, operated by JPL/Caltech under NASA contract 1407. Support for this work was provided by NASA through Contract #1256790 issued by JPL/Caltech.

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