Infrared Dark Clouds in Cygnus-X

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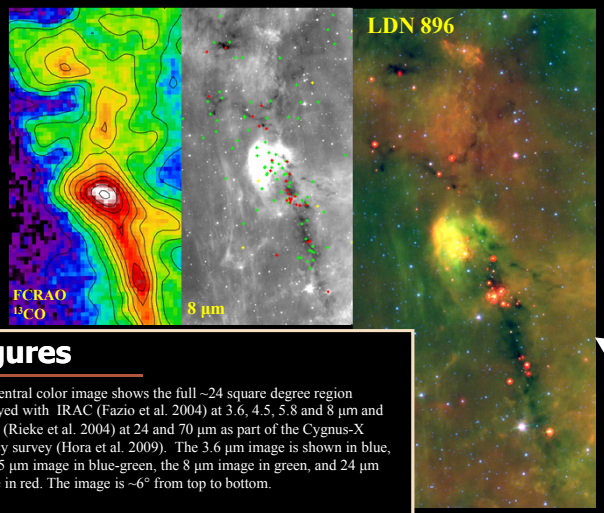
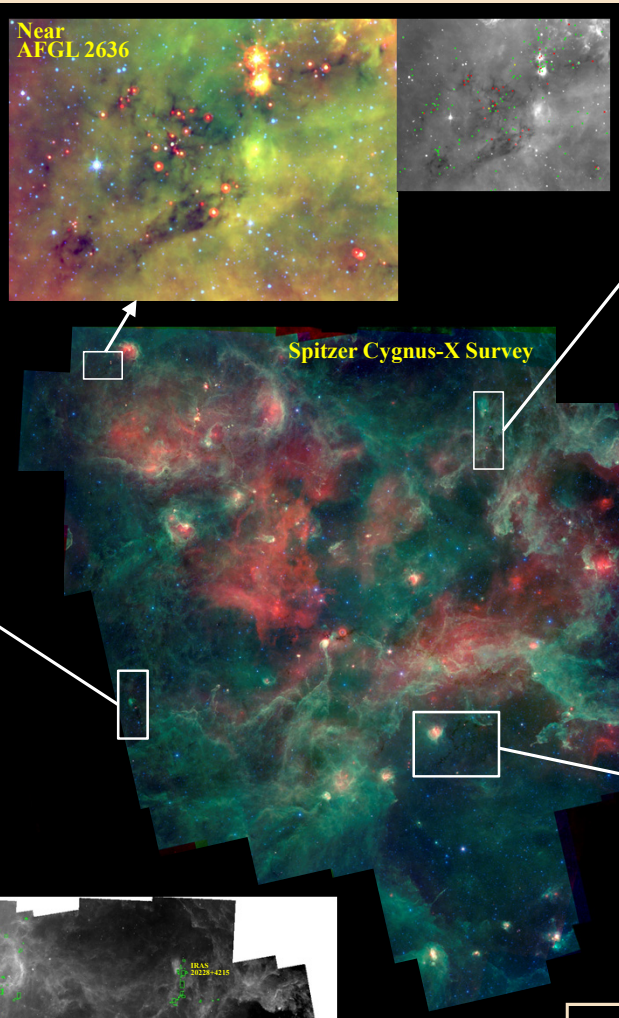
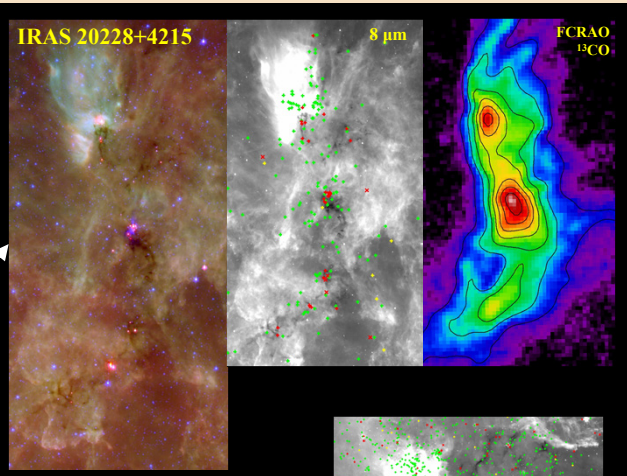
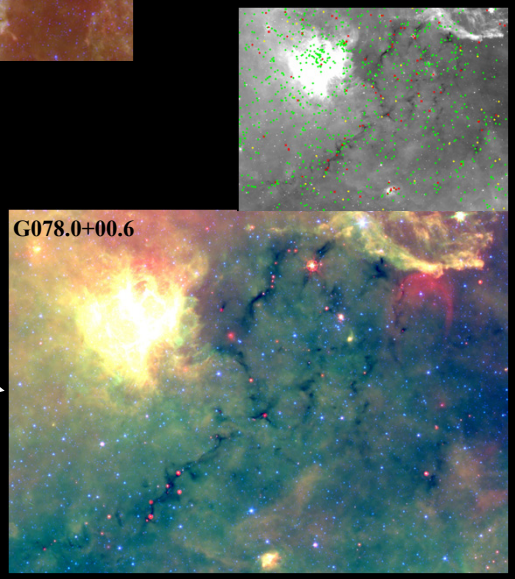
Abstract

As part of the Cygnus-X Spitzer Legacy survey, we have begun a study of the infrared dark clouds (IRDCs) found in the IRAC and MIPS data of the region. Since most of the IRDCs are associated with the Cygnus-X complex at ~1.4 kpc (Rygl et al. 2011), they are closer than most of those observed in the large Galactic surveys, and therefore we can better resolve their structure and detect the population of low-mass young stellar objects (YSOs) that have formed in association with the clouds. We present the results of our study, in which we have located and characterized the population of IRDCs. We have found the embedded YSOs and clusters associated with the clouds, including the 4.5 μm-bright extended sources that indicate outflows from YSOs. We show the distribution of IRDCs in the Cygnus-X complex and their relationship with the other well-known active sites of star formation.







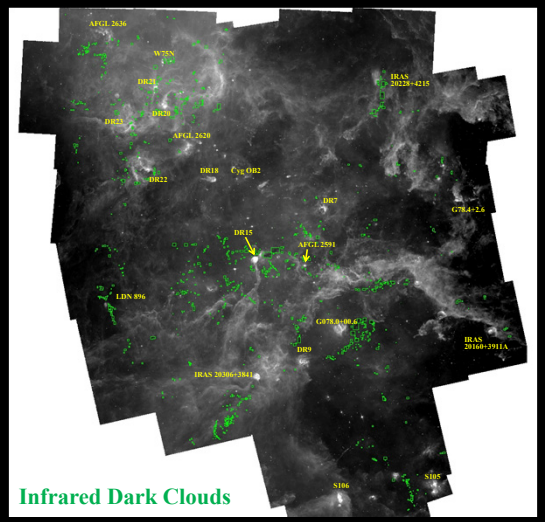


Figures

The central color image shows the full ~24 square degree region surveyed with IRAC (Fazio et al. 2004) at 3.6, 4.5, 5.8 and 8 μm and MIPS (Rieke et al. 2004) at 24 and 70 μm as part of the Cygnus-X Legacy survey (Hora et al. 2009). The 3.6 μm image is shown in blue, the 4.5 μm image in blue-green, the 8 μm image in green, and 24 μm image in red. The image is ~6° from top to bottom.

Below the central image is a greyscale image at 8 μm showing the distribution of clouds throughout the full survey region as determined from our automated search. The search technique finds "dark" regions that fall below a specified threshold value relative to the local background. Once a dark core is found, the extent of the cloud is traced, using a second threshold to determine the cloud size. The IRDCs are marked with rectangular boxes that show the size of the cloud fragment.

Around the central image we have shown four of the IRDC complexes, using the same data but with a different scaling than the main image in order to better show the structure of the clouds. Near each image is a smaller greyscale image of the 8 μm data showing the location of YSO candidates identified from the Spitzer and near-IR data (using the method of Gutermuth et al. 2009). Deeply embedded objects are marked with red Xs, Class I YSOs with red crosses, Class II with green crosses, and yellow crosses for transition and/or debris disk objects . For two of the regions, we also show the ^{13}CO image obtained at the FCRAO (Schneider et al. 2007, 2010) demonstrating the correlation between the molecular gas and mid-IR absorption.



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Results

- Our search for IRDCs in the Cygnus-X region found ~1200 cloud fragments
  - Average size of ~6 pc (ranges from 0.25 – 23 pc)
  - Average mass ~4800 $M_\odot$ (range 4000 – 5×10^5 $M_\odot$) determined from 8μm absorption
- Most (~740) fragments are in complexes which are parts of the same or closely-related IRDC
  - 42 IRDC complexes of 4 or more clouds
  - 13 large complexes (>20 cloud fragments)
- ~150 Extended Green Objects (EGOs) located in or near IRDCs
- Class I and deeply embedded YSOs are found primarily in the densest parts of the IRDCs, along with EGOs
- Clusters of Class II YSOs are often associated with the IRDCs, high Class I/Class II ratio indicates relatively young age of clusters near IRDCs
- With the Spitzer data we have detected smaller clouds and resolved more details of their structure than was previously possible

For more info, visit our project site:
http://www.cfa.harvard.edu/cygnusX

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