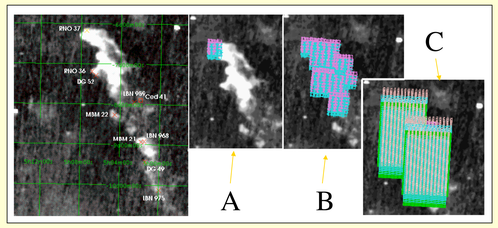
Spitzer Observations of YSO's in the Witch Head Nebula (IC 2118)

T. S. Spuck, M. T. Heath, S. P. Weiser (Oil City Area Senior High School, Oil City, PA), L. M. Rebull (SSC/JPL/Caltech, Pasadena, CA), T.E. Roelofsen Moody (New Jersey Astronomy Center for Education, Somerville, NJ), B. Sepulveda (Lincoln High School, Stockton, CA), C. R. Weehler, (Luther Burbank High School, San Antonio, TX) Send Inquiries To – tspuck@mail.ocasd.org

Abstract: Two high-Galactic latitude molecular clouds (HLC) in the region of IC 2118, the Witch Head Nebula, appear to be forming stars (Kun et al. 2004). Star formation in HLCs, while rare, may be the origin of some of the apparently isolated T-Tauri stars revealed by ROSAT. At only ~210 pc away, the clouds in IC 2118 are thought to be excited by Rigel. Kun et al. (2004) reported the discovery of three T-Tauri stars in this region. Our 2005 pilot project surveyed a 15x15 arc-minute region at the head of the cloud and approximately quadrupled the number of suspected young objects in this region (Spuck et al. 2005). With additional Spitzer Telescope time in 2006, we observed ~2 square degrees further along the nebula. Using color-color plots, we have identified many candidate young objects throughout the nebula. In this poster, we will present color-color plots and SEDs of these stars, criteria for their selection, and discuss follow-up observations at other wavelengths to confirm the status of the suspected young objects. These observations are part of the Spitzer Space Telescope Research Program for Teachers and Students. For additional information on some of our educational products, please see our companion poster by Roelofsen Moody et al.

Methods

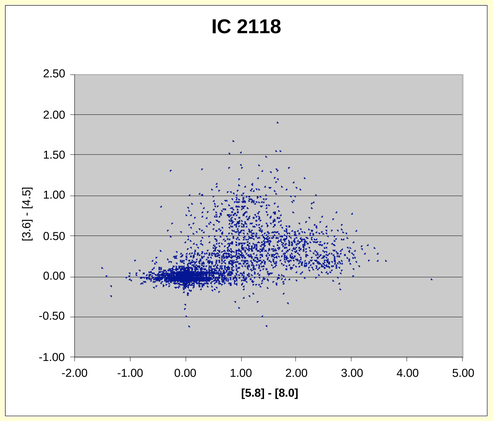
- In March of 2005 this team used the Spitzer Telescope to image a 20 X 20 arcmin area of IC 2118 using the IRAC and MIPS instruments.
- In addition to the three classical T-Tauri sources identified in Kun et al (2004), nine new potential T-Tauri sources were identified using the Spitzer 2005 observations.
- In February 2006 a follow-up proposal was submitted to observe the majority of the remaining cloud.

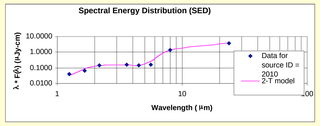


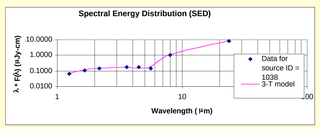
- The figure above shows the region of IC 2118 (in IRAS 25 microns) selected for observation by IRAC and MIPS (with the observations overlaid). The left panel contains an indication of the previously catalogued objects in this region. The second panel (image A) of the figure shows the IRAC coverage from last year. The next panel (image B) includes the IRAC coverage for 2006, and the right panel (image C) shows the MIPS coverage for 2006.
- The data were collected in March 2006.
- The team met at the Spitzer Science Center (SSC), in July 2006, to work with Dr. Rebull to reduce the data.
- The team used SSC software, MOPEX, to create a mosaics and extract sources; we then band-merged the source lists. The source list data table includes 2MASS (J, H, and K bands), IRAC (3.6, 4.5, 5.8, 8 μm), and MIPS 24 and MIPS 70 μm fluxes in both magnitudes and Janskys.
- We imported the data tables into Excel for classroom use.
- We generated color-color plots to identify potential young stars based on degree of infrared excess.
- We constructed Spectral Energy Distributions (SEDs) using IRAC+MIPS (combined with 2MASS) in an effort to discriminate between cluster members and background extragalactic objects.
- We used MaxIm DL to generate tri-color images of the target area.

Acknowledgments: This project was funded by the Spitzer Space Telescope Observing Program for Students and Teachers, a joint project of NASA and NOAO. We also acknowledge the NOAO Teacher Leaders in Research Based Science Education Project funded by the National Science Foundation under ESI 0101982, funded through the AURA/NSF Cooperative Agreement AST-9613615. NOAO is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation.

Results

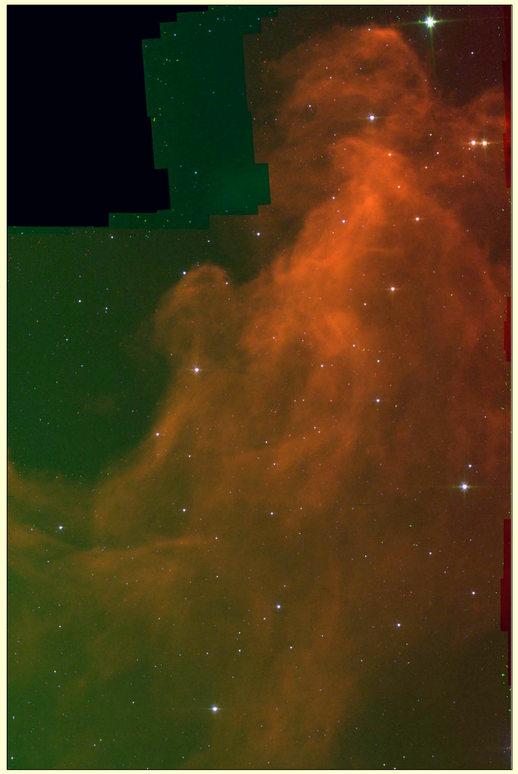






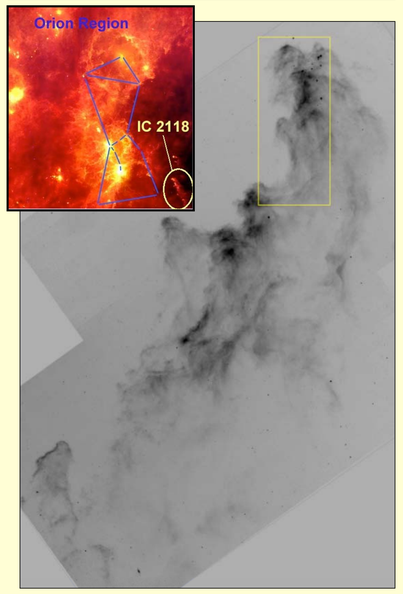
Above: IRAC color-color plot showing YSO candidates; photo-spheres are near (0, 0) and red objects are towards the upper right.

Left: Spectral energy distributions created using 2MASS J, H, and K, IRAC 3.6, 4.5, 5.8, and 8 μm, and MIPS 24 μm data via an interactive Excel spreadsheet created by Russ Laher at the SSC.



LEFT – IC 2118 3.6 μm (blue), 5.8 μm (green), 8.0 μm (red) tri-color composite generated using MaxIm DL. (By M. Heath, N. Kelley, P. Morton, M. Walentosky, S. Weiser – Oil City High School, Oil City, PA)

BELOW – IC 2118 24 μm image (negative grey scale) generated using MaxIm DL. Yellow box shows tri-color composite area.



Using the 2-8 micron slope (following Wilking et al. 2001), we have identified many potential Class I, Class II, and Class III young stellar objects.

Further Study

- Palomar 200 inch telescope time in January 2006 to obtain classification spectra.
- Ongoing I, R, V, B, U and H-alpha observations of candidates using USNO 1.0 M Telescope, Kitt Peak 0.9 M telescope, and C-14 telescopes at Perth Observatory, and New Mexico Skies.