An Infrared Examination of Young Stars in Upper Centaurus Lupus

Chelen H. Johnson[1], Marcella Linahan[2], Jacqueline Barge[3], Luisa M. Rebull[4], Donovan Aranda[3], Nuriel G. Canlas[2], Katherine E. Donahoe[2], Madison K. Ernst[1], Sydney Ford[3], Megan E. Fox[2], Elizabeth Gutierrez[2], Lille W. Haecker[1], Cecily A. Hibbs[1], Maya R. Maddaus[1], Taylor A. Martin[1], Emily Ng[3], Adam P. Niedbalec[2], Sophie E. O'Bryan[1], Elizabeth F. Searls[1], David Zegeye[3], Amanda B. Zeidner[1]

[1]Breck School, Golden Valley, MN, [2]Carmel Catholic High School, Mundelein, IL, [3]Walter Payton College Prep High School, Chicago, IL, [4]Caltech, Pasadena, CA

Abstract

Optical studies of the Upper Centaurus Lupus (UCL) region of the Scorpius-Centaurus (Sco-Cen) complex have shown this region to be rich with young stellar objects. The nearby G/K/M Sco-Cen members have been estimated to be much younger (~5 Myr) than similar star associations. Using archival data from the Spitzer Heritage Archive (SHA), we have extended the data to include the longer, infrared wavelengths. We created spectral energy distributions (SEDs) and color-magnitude diagrams (CMDs) with multiple wavelengths that allow us to search for infrared excess to determine what fraction of these stars have circumstellar disks. Our team used archival Spitzer InfraRed Array Camera (IRAC) and Multiband Imaging Photometer for Spitzer (MIPS), combined with 2-Micron All-Sky Survey (2MASS), and Wide-Infrared Survey Explorer (WISE).

Background

The Scorpius-Centaurus (ScoCen) association is an important site of young stellar evolution. It is the closest star association to Earth at approximately 100-200 pc with an age of ~10 My (Song et al. 2012). The Upper Centaurus Lupus (UCL) cluster is a sub-region of the ScoCen complex along with Upper Scorpius (US) and Lower Centaurus Crux (LCL). This area has shown to have a high concentration of pre-main sequence, low-mass stars (Sartori et al. 2003). It is difficult to distinguish cluster members from the rest of the stars in the galaxy, and moreover the cluster is so close to us that it covers a huge area on our sky. These nearby stars are critical for studying the early stages of star formation, and circumstellar disk and planet evolution (Rodriguez et al. 2011). Song et al. (2012) used spectroscopy to identify cluster members. They proposed 16 stars as candidate members of UCL. We used archival infrared data to investigate the infrared properties of these candidate members.

Methods

Using the Spitzer Heritage Archive (IRAC and MIPS-24 data from the SEIP) and the WISE archive (the AllWISE release), we looked within 2" of each UCL object identified by Song et al. (2012). We identified the counterparts, and combined these data with 2-MASS data to create spectral energy distributions (SEDs). Trend lines were used to determine the slope of the Rayleigh-Jeans side of each curve including all available points between K and WISE-4. We classified SEDs according to Wilking et al. (2001).

Collaboration Across Three Schools

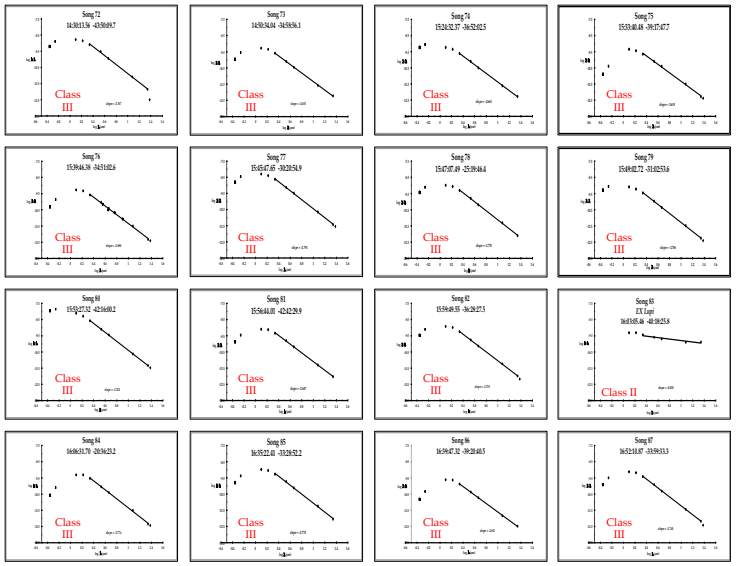
This research project has provided the students with higher-level thinking skills not addressed in a typical high school course. Students achieved insight into how authentic science research is conducted. This project grew out of previous NITARP projects. Three high school teachers and their students collaborated to study these 16 objects in UCL.

Participants from Carmel Catholic High School in Mundelein, IL.

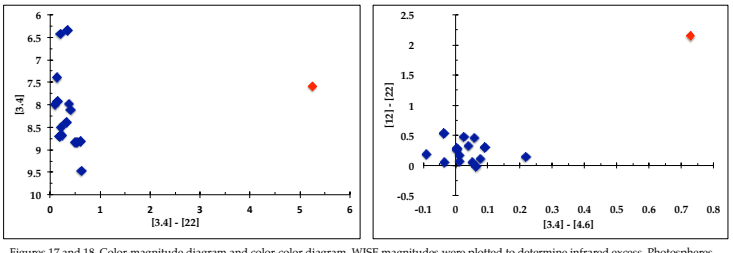
Participants from Walter Payton College Preparatory School in Chicago, IL.

Students from Breck School in Golden Valley, MN.

Results



Figures 1-16. Spectral energy distributions. In all figures, the y axis is log(λF_λ) in ergs/s/cm^2, and the x-axis is log (λ) in microns; stars represent optical data from the literature, diamonds 2MASS data, squares IRAC data, circles WISE data and crosses MIPS-24 data. Fifteen objects are Class III stars without IR excesses, and one is a Class II star (Song 83) – this object was already known to have a disk; it is EX Lupi.



Figures 17 and 18. Color-magnitude diagram and color-color diagram. WISE magnitudes were plotted to determine infrared excess. Photospheres (e.g., stars without infrared excesses or circumstellar dust disks) are expected to have [3.4] - [22] ~0, [3.4] – [4.6] ~0, and [12] – [22]~ 0. Fifteen of the 16 objects do not appear to have significant IR excesses. The red point is Song 83 = EX Lupi.

References

Herbig, G.H. 1977. *ApJ*, 217, 695.
Juhász, A., et al. 2012. *ApJ*, 744, 118.
Rizzuto, A.C., et al. 2012. *MNRAS*, 421, L97.
Rodriguez, D.R., et al. 2011. *ApJ*, 727, 62.
Sartori, M.J., et al. 2003. *A&A*, 404, 913.
Song, I., et al. 2012. *AJ*, 144, 8.
Wilking, B.A. 2001. *ASPC*, 243, 353.

Conclusions & Future Work

Among these objects, only one (Song 83=EX Lupi) has a very large disk, which was previously known (e.g., Herbig 1977). None of the other objects has an infrared excess. We plan to continue working through the list of nearby young stars.