The WISE Census of Young Stellar Objects in Canis Major

Will Fischer (NASA Postdoctoral Fellow), Debbie Padgett, & Karl Stapelfeldt
NASA Goddard Space Flight Center

WISE Search for Young Stellar Objects

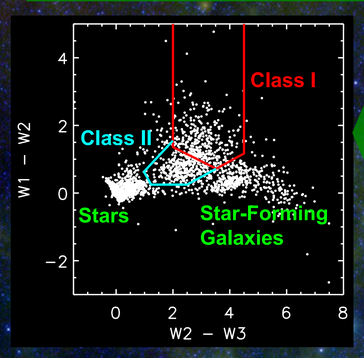
- Spitzer and Herschel teams found thousands of young stellar objects (YSOs) in the nearest kiloparsec, but searches were restricted to the densest parts of molecular cloud complexes
- We are preparing an *all-sky search* for YSOs with WISE
- This will refine the initial stellar mass function and allow a better characterization of star and planet formation in regions with the lowest initial gas densities
- Here we present an initial study of a 100 square degree field centered on the Canis Major star-forming region

Star Formation in Canis Major

- Centered at $b = -2^o$, $\ell = 224^o$ amid the CMa OB1 association; distance ~ 1000 pc; star formation thought to be induced by a supernova (see Gregorio-Hetem 2008 for a recent review)
- Home to 5×10^5 $M_\odot$ of material distributed across 22 clouds as traced by ^{13}CO gas (Kim et al. 2004)
- Not studied comprehensively with Spitzer, although IRAC 3.6 and 4.5 μm photometry have been obtained for much of the field by the GLIMPSE360 warm-mission project
- We perform a WISE search for Class I and Class II YSOs (dusty envelopes and dusty disks, respectively) in a 10° by 10° field around the star-forming region ($102^o < RA < 112^o$, $-16^o < Dec < -6^o$)

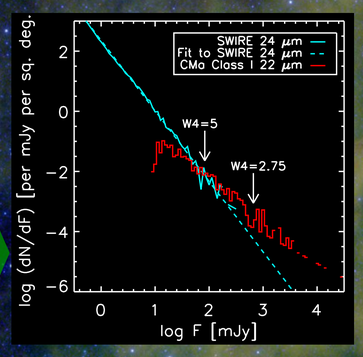
Source Identification

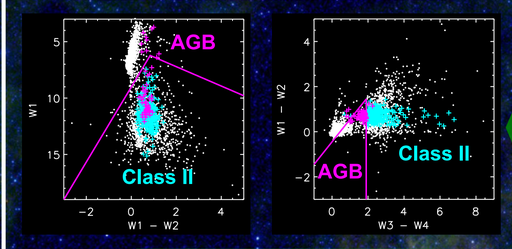
1) With IRSA, we search AllWISE for sources detected in Bands 1, 2, and 4 that lack contamination flags and satisfy S/N and χ^2 requirements (e.g., Band 4 S/N > 6)



2) Class I and Class II candidates are identified by W1–W2 and W2–W3 colors (Koenig & Leisawitz 2014)

3) Based on Spitzer SWIRE counts (Shupe et al. 2008), Class I candidates fainter than W4 = 5 are rejected as likely extragalactic contaminants. (Those brighter than W4 = 2.75 are least likely contaminants.)





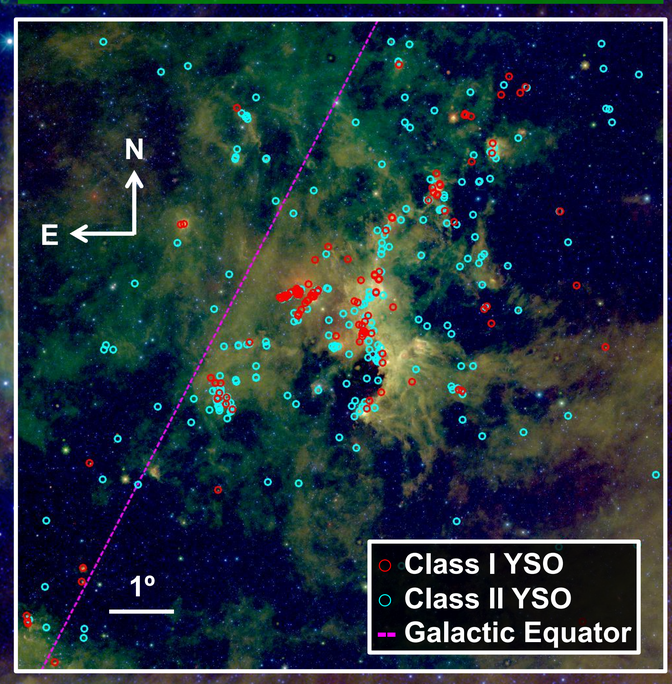
4) Class II sources that fail a color-magnitude or color-color test (e.g., too bright in W1) are rejected as likely AGB stars (Koenig & Leisawitz 2014)

Candidate Tally:
139 Class I sources
245 Class II sources

Background Image

A 10° × 10° WISE image centered on the Canis Major star-forming region. Blue is 3.4 μm, green is 12 μm, and red is 22 μm. The cyan-boxed region is discussed below. (Made with IPAC *Montage*)

YSO Map



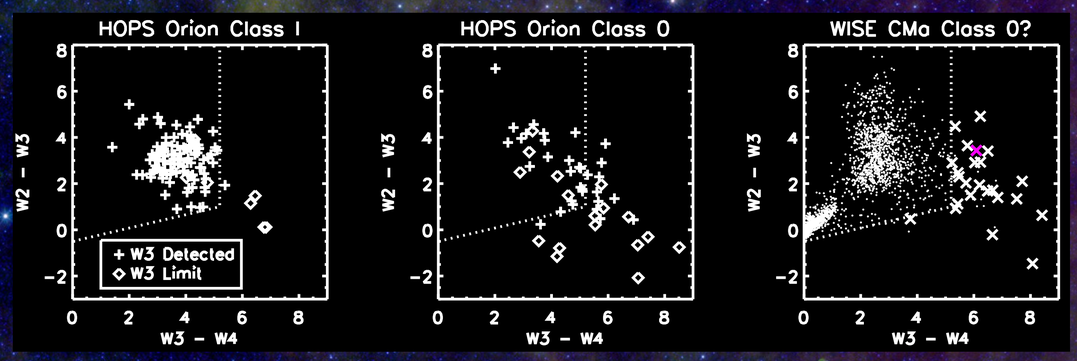
- YSOs are concentrated at the sites of ^{13}CO clouds (Kim et al. 2004)
- Median nearest-neighbor distance smaller for Class I (0.60 pc) than Class II (1.5 pc)
- Ratio of Class II to Class I is 1.76 over the entire field but drops to 0.72 for clustered sources (nearest neighbor < 0.5 pc)

Conclusions

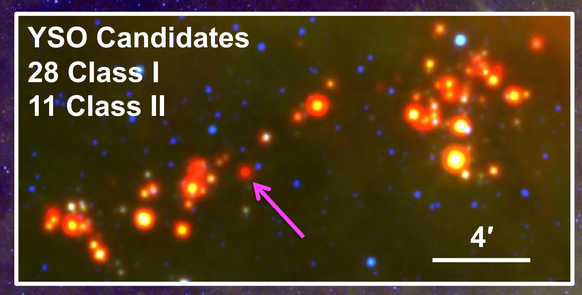
- We find a distributed population of ~ 100 Class II YSOs with nearest neighbor > 2 pc
- We find 2–3 associations of Class 0/I YSOs outside the well known CMa R1 region
- Tools are in place for analysis of other star-forming regions and an all-sky search

Finding Class 0 YSOs with WISE

- Identifying the youngest YSOs, with SEDs that peak beyond 100 μm, is difficult with photometry ≤ 22 μm
- Roughly speaking, Class 0 YSOs have most of their mass still in their envelope, and Class I YSOs have most of their mass in the central star
- We use the population of Orion protostars characterized by Spitzer and Herschel photometry (Megeath et al. 2012; Fischer et al. 2013; Manoj et al. 2013; Stutz et al. 2013) to distinguish between WISE Class 0 and Class I YSOs
- Deep silicate absorption in Class 0 YSOs yields blue W2–W3 colors, red W3–W4 colors, and frequent W3 nondetections



WISE colors of Class I (*left*) and Class 0 (*center*) YSOs from HOPS, the Herschel Orion Protostar Survey. Sources below or to the right of the dotted lines are predominantly Class 0. *Right:* Same colors for all WISE CMa point sources. Xs mark 24 sources (with W4 brighter than 5 mag) that are Class 0 candidates. The magenta symbol marks the source discussed to the right.



- Previously unreported association of very red sources in CMa (see boxed region in background image)
- Reddest source (at arrow) has WISE colors and magnitudes consistent with a very young 4 $L_\odot$ Class 0 protostar at 1000 pc

References: WJ Fischer et al 2013, AN 334, 53; J Gregorio-Hetem 2008, Handbook of SF Regions Vol. 2, 1; BG Kim et al 2004, PASJ 56, 313; XP Koenig & DT Leisawitz 2014, ApJ 791, 131; P Manoj et al 2013, ApJ 763, 83; ST Megeath et al 2012, AJ 144, 192; DL Shupe et al 2008, AJ 135, 1050; AM Stutz et al 2013, ApJ 767, 36