CWAYS – Cool, WISE, and Young Stars: A NITARP 2012 search for YSOs using primarily WISE data

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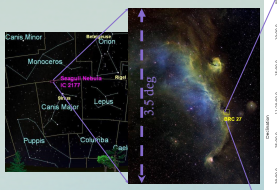
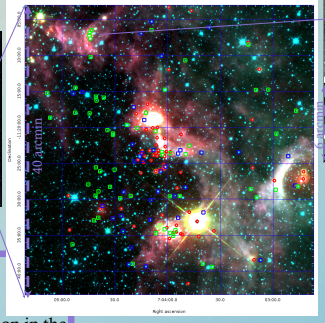
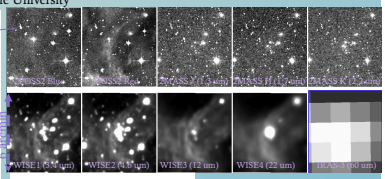
Abstract

We searched for new candidate young stellar objects (YSOs) primarily using the March 2012 all-sky release of Widefield Infrared Survey Explorer (WISE) data. We searched in BRC 27, which is part of CMa R1, a region of known star formation. We investigated WISE data within a 20 arcminute radius of BRC 27 (~0.35 sq. deg), combining it with serendipitously obtained Spitzer data in this region, 2MASS data, and optical data.







Background

- Stars form from clouds of interstellar gas and dust.
- During star formation, a dusty circumstellar disk forms around the YSO, creating excess emission in the IR beyond that expected from the central object alone. We can identify young stars from this IR excess emission.
- YSOs can be classified into 4 classes based on spectral energy distribution (SED) shape (amount of IR excess), thought to be tied to degree of embeddedness.
- BRC=Bright Rimmed Cloud; Sugitani et al. (1991) identified set of objects: dusty clouds, bright rims, IRAS source behind rim. We study BRC 27, in CMa R1.
- Is the star formation here triggered, or collapsing under its own gravity? If triggered, there might be less-embedded YSOs closer to (still as-yet unknown) trigger source, and more-embedded sources further from trigger. Need more YSOs in wider region to tell.
- Some YSO surveys in literature here, but largely not using IR. Do those previously identified YSO candidates have disks?
- New data from WISE enable searching for YSOs (new and known) over a larger region than previously possible.

Method

- WISE color selection mechanism (Koenig et al. 2012) to select YSO candidates with infrared excess from all sources within 20 arcminute radius around BRC 27.
- Catalog of previously known literature-identified candidate YSOs assembled. Prior surveys used UBV, X-rays, NIR and Halpha; small survey on 5'x5' central region using Spitzer data conducted by prior NITARP team (Rebull et al. 2013, AJ, 145, 15). Objects matched to Two-Micron All-Sky Survey (2MASS) images, coordinates updated.
- Catalog of literature sources matched to WISE+2MASS catalog, tagged new and literature YSO candidates.
- Several serendipitous Spitzer observations in this region, including observations reported in Rebull et al. (2013). New photometry performed on all available Spitzer archival data.
- Visual inspection of remaining candidates in all available images (POSS, 2MASS, WISE) to omit spurious sources, obvious galaxies.
- Inspection of remaining candidates' spectral energy distributions (SEDs) to omit spurious sources, obvious galaxies, determine if literature YSOs have IR excess. Fit a line to the SED to determine SED class (I, flat, II, III).
- Color color diagrams and color magnitude diagrams to further assess candidates.
- Final product: list of new YSO candidates, literature YSO candidates with IR excesses.

Results

3827 objects in BRC 27 region detected by WISE in a 20' radius from 07:03:59, -11:23:09

181 sources with colors like YSOs with an IR excess, as per X. Koenig method, includes 32 previously identified YSOs

68 previously identified YSOs with WISE colors that were not picked out by the method as being YSOs

21 sources we added for consideration based on properties in images

3578 sources likely to be AGN, PAH galaxies, plain stars (without IR excess), false sources, etc.

Toss out

60 new candidate YSOs (we have the most confidence in 11 of these)

62 literature YSOs with IR excess

38 literature YSOs without believable IR excess

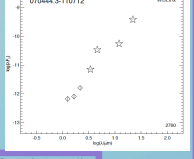
110 sources dropped as unlikely YSOs based in images or SEDs. (e.g., not a believable source, or too much nebulosity)

Toss out

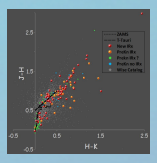
These sources can be subdivided into SED classes:
- Class I : 16 (10%)
- Flat : 24 (15%)
- Class II : 89 (56%)
- Class III : 31 (19%)

In this region, 31 more previously-identified YSO candidates from the literature are not detected by WISE and are thus not included in these counts of objects.

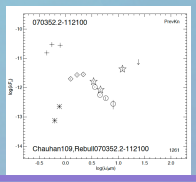
↑Above: 3-color WISE image (R=W4, G=W2, B=W1) of the region we studied. Overlaid symbols: red diamonds = things we identify as new YSO candidates, green boxes = things from the literature that we identify as having a possible IR excess, blue boxes = things from the literature that don't seem to have an IR excess.



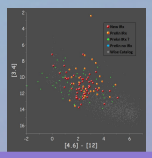
↑Above: Multiband view of one of our new YSO candidates. IRAS are included for comparison, and to demonstrate vast improvement brought by WISE!
← Left: SED of this object, which appears very embedded. (diamonds= 2MASS JHK, stars= WISE1234).



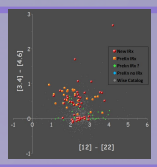
←Left: J-H vs. H-K color-color diagram for our catalog and the new/previously identified YSO candidates. *Our new YSO candidates are largely in the region where we expect YSOs* – red in both J-H and H-K. Several of the literature YSOs do not appear to have much IR excess and may actually be contaminants (non-YSOs).



↑Above: literature YSO SED where Spitzer data (circles=IRAC) resolves source confusion present in WISE data (stars). This is why we supplemented our work with Spitzer data where possible. Diamonds=2MASS, asterisk and plus signs=literature optical.



(↑above) W1 ([3.4]) vs. W2-W3 ([4.6]-[12]) and (↓below) W1-W2 ([3.4]-[4.6]) vs. W3-W4 ([12]-[22]) for our catalog and the new/previously identified YSO candidates. *Our new YSO candidates are largely in the regions where we expect YSOs*, e.g., red and bright (above; galaxies are red and faint), red in both colors (below). The figure below shows many objects with photospheric [3.4]-[4.6] and a variety of [12]-[22] colors. These are typically the most suspicious candidates.



Next Steps:
- Obtain optical data (Sloan r, i bands) from the Las Cumbres Observatory Global Telescope network to further constrain SEDs, assess object morphology in images.
- Spectroscopy of candidates to confirm/refute their YSO status.
- Examine distribution on sky to see if we can find evidence for older/less embedded things closer to the trigger than younger/more embedded things.

←Scan this to get an electronic copy of our poster. Please also see our companion education poster Bonadurer et al., at 246.07.

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