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

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Abstract

All stars originate from clouds of interstellar gas, but the mechanism responsible for formation can vary dramatically depending on the cloud and its environment. For example, if a cloud is massive enough that the gas pressure can no longer support it, gravitational collapse will occur without any external help. In triggered star formation, however, the collapse of a cloud is initiated by external pressure from a nearby star, supernova, or even collision with another cloud. When the external pressure is a shock or ionization front, it pushes away the lower density material faster than the higher density core material. When the external source is bright

stars, it can illuminate the rims of the cloud. Energy from nearby stars not only causes bright rimmed clouds (BRC) to be visible at optical wavelengths, but may also provide an impetus for triggered star formation. We propose to use infrared excess to search for candidate young stellar objects (YSOs) using newly released Widefield Infrared Survey Explorer (WISE) data in three such BRCs, all of which are in regions of known star formation: BRC 27 (with many known young stars), BRC 34 (a less dense star forming region), and BRC 38 (with many known young stars). The Spitzer Archival data was studied by Johnson et al. (2012; a 2011 ***N***ASA ***I***pac ***T***eacher ***A***rchive ***R***esearch ***P***rogram [NITARP] team) and Rebull et al. (2012, in prep) for BRC 27 and BRC 34 and by Choudhury et al. (2010) for BRC 38, providing verification for data analysis and results. We will study the larger region around each of these BRCs using WISE data. We will also process and analyze serendipitous Spitzer data found for these three regions. Based upon our analysis, and in combination with existing data in the literature, we propose to look at the properties of previously identified YSOs as well as identify new YSOs.

1. Science Background and Context: BRCs and YSOs

Enormous clouds of gas and dust serve as the birthing places of stars in galaxies throughout our Universe, including the origin of our own star and Solar System. Studying these clouds becomes important in the quest to answer the question of why certain stars form planets, and why others don't. Since it isn't possible to watch one star's full evolution from its beginning to its end or even its evolution from its beginning to a main sequence star with planets, it is desirable to identify as many young stars as possible and study their conditions and properties in an effort to constrain and understand the evolution of stars in general. While the exact mechanisms of star birth and evolution are not completely understood, it is believed that stars are conceived either through collapse on their own due to self-gravity, bringing together large enough masses to result in fusion, or they are more dramatically triggered via outside influences such as radiation-driven implosions (RDI) (Sugitani et al. 1991).

Star formation can occur in regions of dense gas and dust called cold dark nebulae. The temperatures of these nebulae are approximately 10 K to 100 K (Maoz 2007). The low kinetic energy of the gas and dust particles allows them to form clumps which gradually increase in size. This mass increase causes an increase in gravitational attraction, which in turn causes more mass to fall on the clump, eventually forming a protostar. This process could be occurring in multiple regions in the dust cloud, at various stages and rates, producing from one to hundreds of thousands of protostars, depending on the size and mass of the dust cloud. This process could be triggered, or accelerated, by the presence of a nearby bright star.

Bright rimmed clouds (BRCs) are a type of cold dark nebula with illuminated "bright rims" that can be seen at optical wavelengths due to the influence of energy from nearby massive stars. They consist of a denser head that appears with a bright rim and less dense tail region (Sugitani et al. 1991). They are associated with HII regions that are approximately 10^6 yrs old (Sugitani et al. 1991). BRCs may have been dense regions in a larger molecular cloud that were revealed and disturbed by UV radiation emitted from O or B type stars (Sugitani et al. 1991). While BRCs are considered densely packed with dust in the astronomical sense, Maoz presents a comparison that these clouds, "are many orders of magnitude lower than the density of the best vacua achievable in the laboratory" (Maoz 2007 pg. 114). The gas and dust are excited by the UV radiation emitted from O or B type stars associated with the dust cloud (Sugitani et al. 1991). Star formation is most likely triggered by the UV radiation and strong stellar winds from the associated O and B type stars which compress and ionize the material.

BRCs also provide a glimpse of star formation at different stages. Young stars are placed into groups on the basis of the slope of their spectral energy distribution (SED). SEDs are a representation of the amount of energy being emitted by the stars as a function of different wavelengths. YSOs tend to deviate from the typical black body curve on the longer wavelength (cooler) end of the curve due to infrared emissions of surrounding (circumstellar) dust. The infrared excess is the difference between the energy of the dust surrounding the star and the energy of the young star. On the basis of the SED slope between 2 and 24 microns, the stellar evolution of YSOs can be categorized in one of the phases of stellar formation; that is: Class 0, Class I, Flat, Class II and Class III protostars. Larger slopes suggest a larger infrared excess, e.g., more infrared than would be expected from an unadorned photosphere (plain star) of comparable temperature. The largest IR excesses are found in the most embedded (presumably youngest) Class 0 protostars, which lie deep within their cocoon of dust and gas. The next less embedded stages are Class I with a positive SED slope, followed by the Flat class with a relatively flat slope. The amount of circumstellar dust continues to decrease around Class II and Class III objects, which have increasingly negative SED slopes. The IR excess becomes less prominent as stars move through Class I, flat, II, and III. The amount of IR excess may be tied to age, and in the case of the BRCs, where star formation may be triggered, it could also be related to the (projected) location of the YSOs. There is some evidence (Ogura et al. 2002) that the youngest stars that are very bright in IR are typically located near the head of the cloud, and bluer, older stars are located closer to the O or B type star. This suggests an evolutionary transition in the cloud known as small-scale sequential star formation (Ogura et al. 2002). This research will look for such a correlation. However, with such a small sample size of stars, it may be that no definite conclusions can be made.

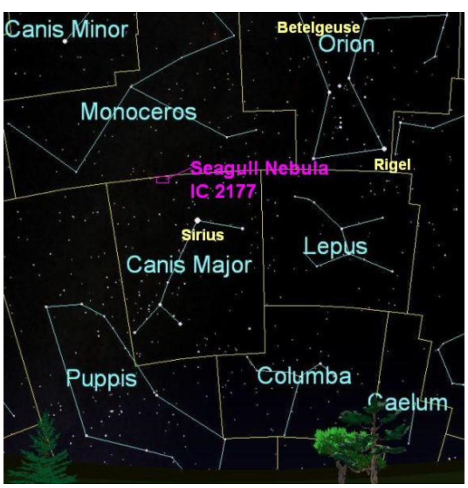
2. This study

The goal of this study is to use apparent infrared (IR) excesses to identify new young stellar objects (YSOs) in BRC 27, BRC 34, and BRC 38, and to compare these results to previously identified young stellar objects in these regions. Because there have been several prior studies in each of these regions, we expect several of our IR-selected YSO candidates to have already been identified in the literature. However, we also expect to find additional YSOs in the area around all three of our targets. We will compare the data from WISE to the existing Spitzer Space Telescope (Werner et al. 2004) data in the (small) areas of space that the data overlap. The data comparison in these overlapping regions will allow us to re-discover existing YSOs, as well as add points to the SED of YSO candidates. Data from additional sources, as discussed in section 3, will be used to eliminate background galaxies as candidate YSOs and allow us to produce more robust SEDs.

This work in BRC 27 and 34 is to some extent a continuation of the work done on BRC 27 and 34 by Johnson et al. (2012; a 2011 NITARP team) and Rebull et al. (2012, in prep). That previous work used Spitzer to identify new YSOs and identify IR excesses in previously identified YSOs. Our new research will extend this focus by primarily using WISE (Widefield Infrared Survey Explorer; Wright et al. 2010) data in the outer regions of BRC 27 and 34 (within 15-20 arcminutes radius), which are not covered by Spitzer data, and which were not studied by Johnson et al. (2012). We will be able to add WISE points to the SED of the objects they discovered, and we will be able to test our YSO selection mechanism by comparing what we find to what they found.

In addition to BRC 27 and 34, we will study BRC 38, using all the data available to us, including specifically Spitzer and WISE. BRC 38 is another region of ongoing star formation, part of the same complex as BRC 34, that has many of the interesting activity characteristics of YSO formation (Choudhury et al. 2010).

2.1 BRC 27



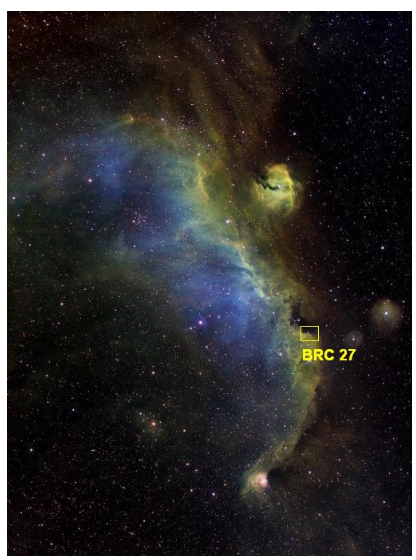


Figure 1: *LEFT*: BRC 27 lies in the Seagull Nebula, or IC 2177. It is on the border of Canis Major (The Great Dog) and Monoceros (the Unicorn). Orion the Hunter is also nearby. The bright star Sirius is located below the nebula. The image here was created using Starry Night software and Paint. *RIGHT*: An optical view of the Seagull Nebula (from http://www.global-rent-a-scope.com/gras-gallery/nebula-magic/9111699), with an annotation for BRC 27 included.

BRC 27 is a bright rim within the molecular cloud CMa R1, located at 07h03m39s -11d23m43s. It is part of the Canis Major constellation, and part of the Seagull Nebula (IC 2177); see Figure 1. This star forming region is believed to be an RDI morphology (see, e.g., Sugitani et al. 1991), although exactly what object(s) triggered the star formation is not certain at this time (Gregorio-Hetem et al. 2009).

Several previous studies have identified stars using various techniques and identified different sources. Wiramihardja et al. (1986) used UBV photographic photometry in this larger area. Sugitani et al. (1991) – the origin of the BRC nomenclature – used IRAS sources combined with Palomar Observatory Sky Survey (POSS) plates to identify bright rimmed clouds likely to be sites of triggered star formation. Soares & Bica (2002, 2003) determined a distance of ~1.2 kiloparsecs and an age of ~1.5 Myr for the stars in BRC 27 using an early version of the Two-Micron All-Sky Survey (2MASS) catalog. This distance is consistent with the findings of Shevchenko et al. (1999), who used photoelectric photometry(!) and objective prism spectroscopy in this region to identify YSOs. A wide field X-ray study of the CMa OB1/ R star forming region done by Gregorio-Hetem et al. (2009) identified several low mass YSOs using X-rays. Chauhan et al. (2009) used BVI_c photometry, as well as 2MASS JHK_s and Spitzer Infrared Array Camera (IRAC) data, to identify stars and compare the ages of stars inside and outside the rims. They suggest that there is evidence of an RDI mechanism. We note that Chauhan et al. (2009) used archival IRAC, but not MIPS data, and moreover did not use the IRAC data as a primary mechanism to select YSO candidates; they used near-IR JHK colors to identify candidates. Johnson et al. (2012) and Rebull et al. (2012, in prep) used the mid-IR IRAC and MIPS colors to search for YSOs in a ~5'x5' footprint. They identified IR excesses around 21/33 previously-known YSO candidates in this small region and identified 19 entirely new YSO candidates.

As mentioned above (and below), we will use WISE data to survey a larger region of BRC 27 (~15-20 arcmin diameter) around the relatively small ~5'x5' 4-band IRAC footprint from Spitzer to (a) look for IR excesses around previously-identified YSO candidates, and (b) look for new YSO candidates using the WISE bands. Figure 2 shows the Spitzer 4-band IRAC footprint and a comparable region from WISE for comparison. Since the WISE data survey will cover a larger region than the relatively small region studied by Johnson et al. (2012) and Rebull et al. (2012), it will enable us to put the previous analysis into context by looking at the larger environment around BRC 27 itself – e.g., begin to address the following questions: in the 4-band Spitzer area of BRC 27, the surface density of YSOs is ~1.6 YSOs per square arcminute (Johnson et al. 2012, Rebull et al. 2012); is there as high a surface density of YSOs outside of the IRAC footprint? How quickly does the YSO surface density fall off? Are there proportionally more Class IIs than Class Is farther from the center of the BRC?

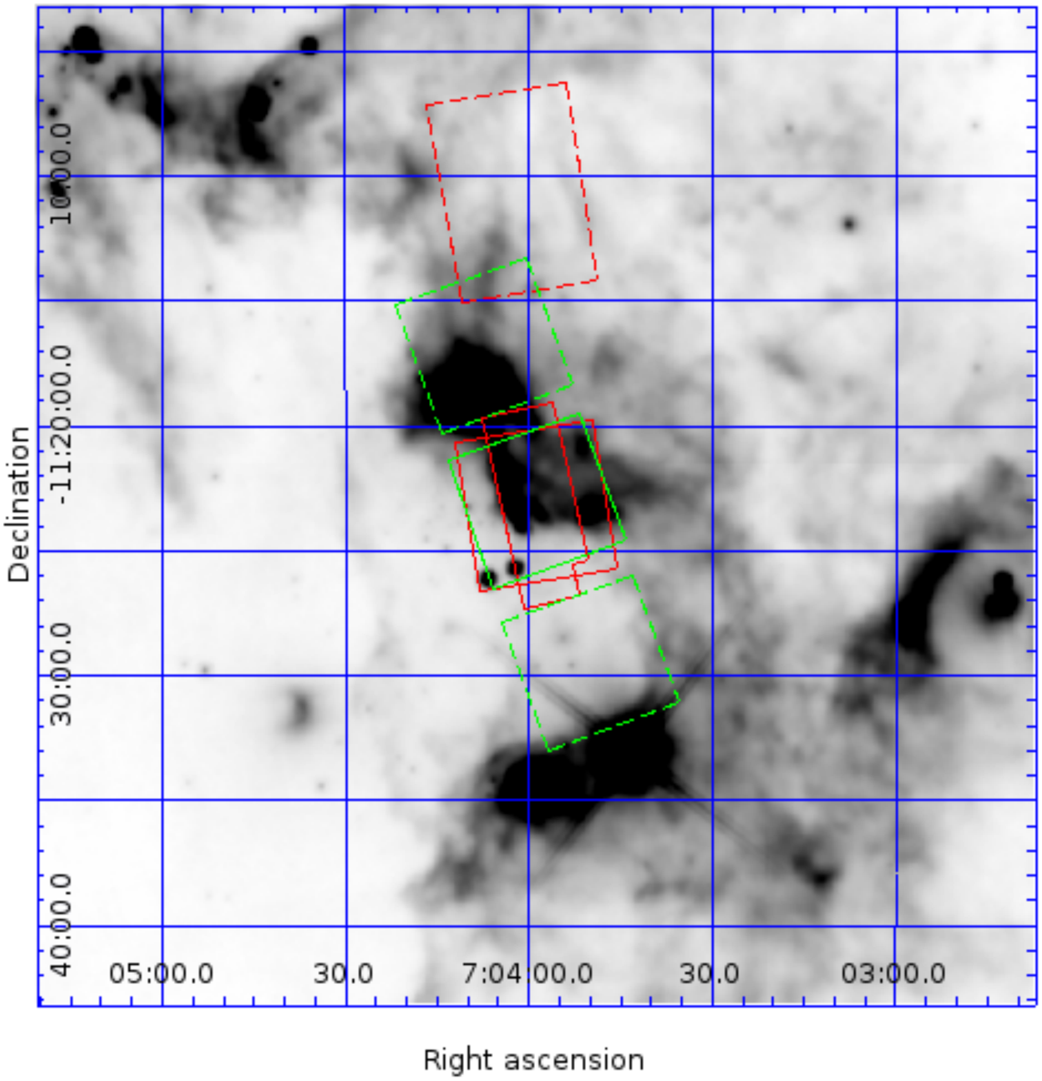


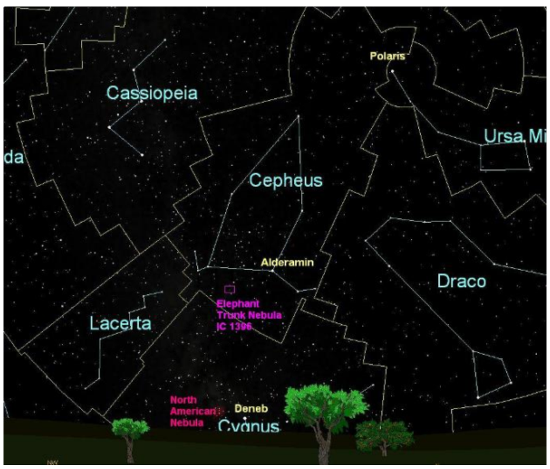
Figure 2: The BRC 27 region in WISE-4 (22 microns; reverse greyscale). This image is ~40 arcmin on a side, e.g., the region we will be exploring. The center solid green square indicates the region with 4-band IRAC data from Johnson et al. (2012) and Rebull et al. (2012, in prep); the dashed green squares indicate the regions of serendipitously obtained 2-band IRAC coverage. The larger red square in the center is the region of MIPS-24 coverage; the dashed red rectangle is the region of serendipitously obtained MIPS-24 data. The irregular smaller red polygon in the center is the region of MIPS-70 coverage.

2.2 BRC 34

BRC 34 is located in the northern constellation Cepheus in the IC 1396 complex, near the Elephant's Trunk Nebula; see Figure 3. It is estimated to be at a distance of

0.75 kiloparsecs. (Sugitani 1991). Two H-alpha emission stars were found in BRC 34 by Ogura et al. (2002) by grism spectroscopy and narrowband imaging.

Using the Isaac Newton Telescope (INT) Photometric H-Alpha Survey (IPHAS), Barensten et al. (2011) found many star candidates in the entire IC 1396 complex that are believed to have been triggered by the massive star HD 206267. However, BRC 34 (known as cloud D in the study) was not listed as a particular region for new star candidates, and they found relatively few objects there. Nakano et al. (2012) also searched for stars bright in H-alpha over the whole complex, and in the BRC 34 region, rediscovered one of the sources found by Ogura et al. (2002). Johnson et al. (2012) and Rebull et al. (2012, in prep) found that Ogura source plus 8 new IRAC-selected YSO candidates here. BRC 34 does not appear to have as high a YSO density as BRC 27.



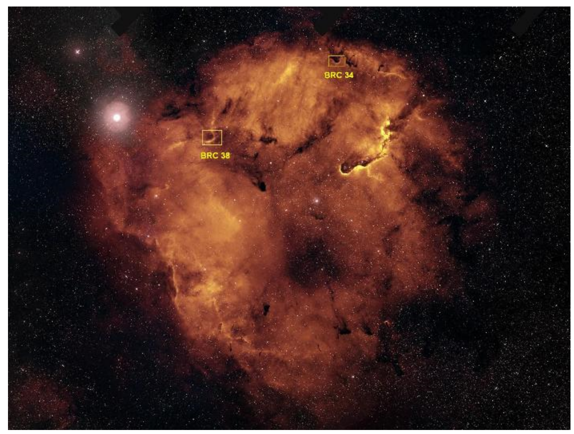


Figure 3: *LEFT*: BRC 34 and BRC 38 lie in Cepheus the King, the nearest bright stars are Alderamin and Deneb. This image was created using Starry Night software and Paint. *RIGHT*: We have updated this r, i, and Halpha image from IPHAS and Berentsen et al. (2011) to show the locations of BRC 34 & 38 in IC 1396 – the Elephant Trunk Nebula. We note that BRC 38 has a brighter rim than BRC 34.

As for BRC 27 above, we will use WISE photometric data to survey a larger region of BRC 34 (~15-20 arcmin diameter) around the relatively small ~5'x5' 4-band IRAC footprint from Spitzer, and put the relatively small region studied by Johnson et al. (2012) and Rebull et al. (2012 in prep), into context by looking at the larger environment around BRC 34. Figure 4 shows the 4-band IRAC image from Spitzer and a comparable image from WISE. In the 4-band Spitzer area of BRC 34, the surface density of YSOs is much lower than BRC 27, at only ~0.4 YSOs per square arcminute (Johnson et al. 2012, Rebull et al. 2012). We expect this trend to continue outside the Spitzer footprint, and do not expect to find many more YSOs in this region.

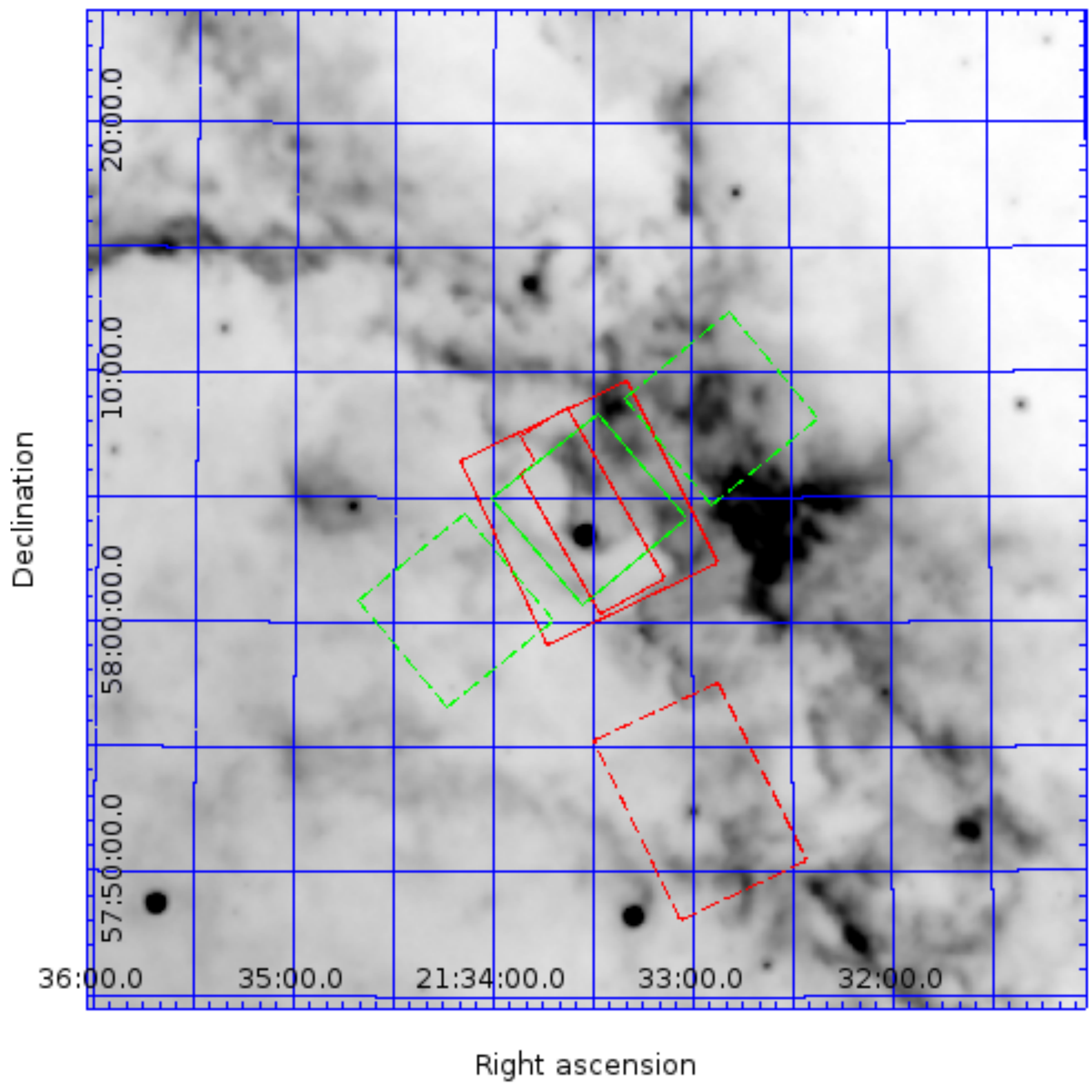


Figure 4: The BRC 34 region in WISE-4 (22 microns; reverse greyscale). This image is ~40 arcmin on a side, e.g., the region we will be exploring. The notation here is as for Figure 2; the center solid green square indicates the region with 4-band IRAC data from Johnson et al. (2012) and Rebull et al. (2012, in prep); the dashed green squares indicate the regions of serendipitously obtained 2-band IRAC coverage. The larger red square in the center is the region of MIPS-24 coverage; the dashed red rectangle is the region of serendipitously obtained MIPS-24 data. The irregular smaller red polygon in the center is the region of MIPS-70 coverage.

2.3 BRC 38

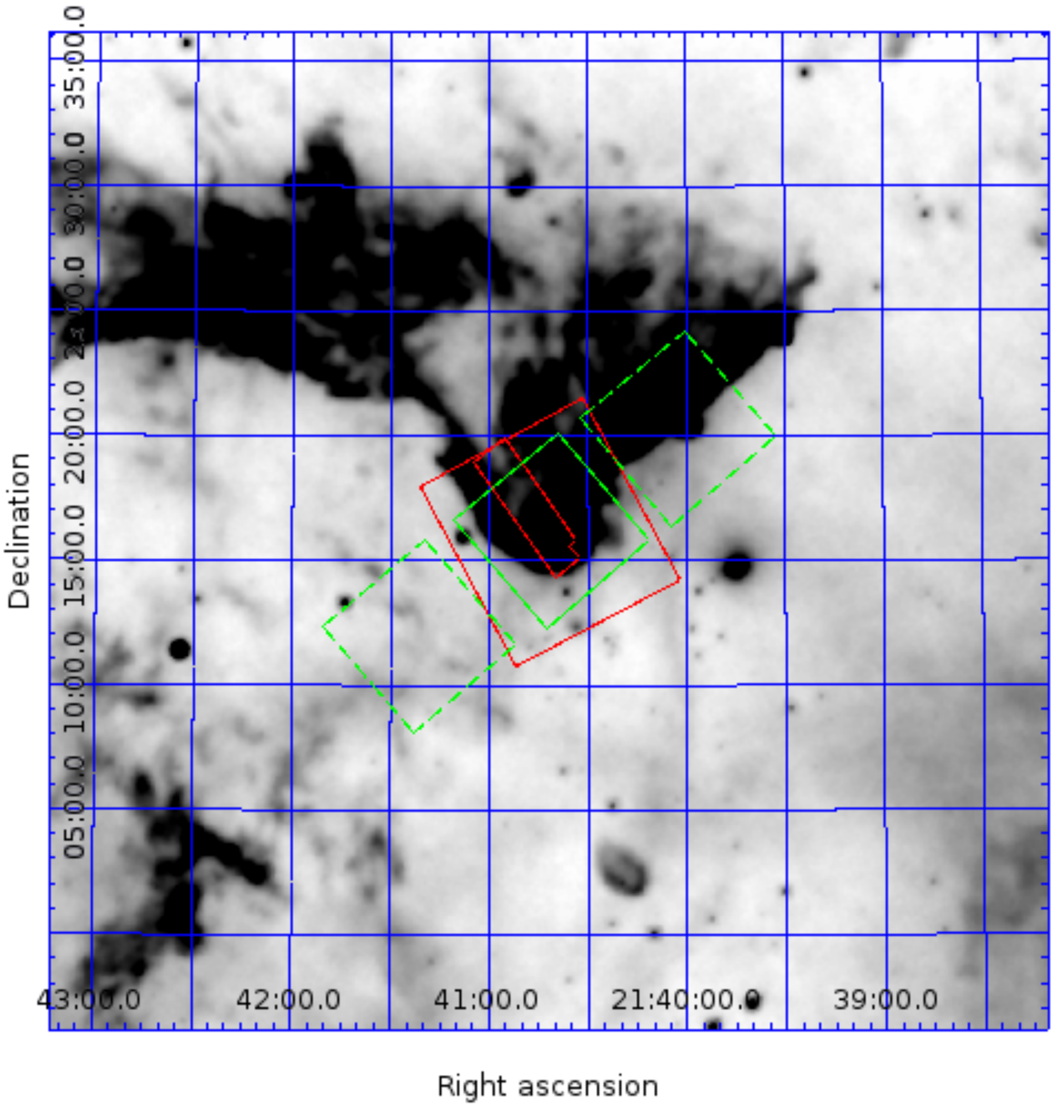


Figure 5: The BRC 38 region in WISE-4 (22 microns; reverse greyscale). This image is ~40 arcmin on a side, e.g., the region we will be exploring. The notation here is similar to that for Figures 2 and 4; the center solid green square indicates the region with 4-band IRAC data from Choudhury et al. (2010); the dashed green squares indicate the regions of serendipitously obtained 2-band IRAC coverage. The larger red square in the center is the region of MIPS-24 coverage. The irregular smaller red polygon in the center is the region of MIPS-70 coverage.

BRC 38 is also located in the HII complex IC 1396 (see Figure 3 above). Since it is located in the northern part of IC 1396 is it often referred to as IC 1396-N. It has a C shape with the southern edge as the brightest part (Pottasch et al. 1956; see Figure 5). Ogura et al. (2002) mention that this cloud is extremely complicated, including multiple outflows and embedded YSOs. Intermediate mass protostars have been found there, though some (Ogura & Sugitani 1999) suggest there is probably a lot of low mass formation going on too. Wang et al. (2009) believe there is also potential for high mass stars formation. H_2 jets have been found here (Saraceno et al. 1996 and Nisini et al. 2001) as well as Herbig-Haro objects (Repurth et al. 2003; Nisini et al 2001). The Infrared Astronomical Satellite (IRAS) located the strongest source at 21391+5802, also known as BIMA 2, which is now thought to be a low mass Class 0 source (Beltran et al. 2002, 2004). This source has H2 emission in the form of bow shocks (Connelley, et al. 2006). These characteristics all indicate this source is a young object (Beltran et al. 2002).

BRC 38 has been observed with IPHAS (r,i,H-alpha; Barensten et al. 2011), Spitzer (3.6-8 microns; Choudhury et al. 2010), and 2MASS (1-2 microns; Beltran et al. 2002). A survey with VLA and BIMA (Beltran et al. 2002) found three intermediate-mass YSO sources in different stages of evolution. A Chandra X-ray study found over 100 X-ray sources in IC 1396N (Getman et al. 2006). About a quarter of those are associated with YSOs, representing a variety of stages (transitional Class 0/I protostars, Class I protostars, transitional Class I/II star, Class II classical T Tauri stars and Class III T Tauri stars). One of the youngest sources detected in X-rays, #66, is found close to the source IRAS 21391+5802 (Getman et al. 2006). A recent study by Nakano et al. (2012) also searched the entire complex for H-alpha-emitting stars; H-alpha emissions are also indicative of young stars. They found that 5 of Getman's X-ray sources in BRC 38 matched H-alpha stars they observed.

As for our other targets above, we will use WISE photometric data to survey a larger region of BRC 38 (~15-20 arcmin diameter) around the relatively small IRAC footprint from Spitzer. In this case, we will investigate in detail the Spitzer data analysis presented by Choudhury et al. (2010) and assess whether we can use it as published (as we will for the Johnson et al. results in the other two clouds), or if we need to re-do the analysis. In either case, the WISE data will enable us to put the relatively small Spitzer region into context by looking at the larger environment around BRC 38. Figure 5 shows one of the IRAC images out of the Spitzer Heritage Archive, and a comparable image from WISE. The red boxes in the images show regions where Spitzer data was obtained with the center box representing the originally targeted area. Data in all four IRAC bands was obtained for the targeted central region through pointings of the 3.6/5.8 micron and the 4.5/8 micron field of views respectively. Serendipitously obtained data in only one of the fields of views in the flanking regions will also be used to expand the region for YSO searches.

<u>3. Analysis Plan</u>

The main focus of our analysis will be WISE data within a ~15-20 arcminute radius around our three targets, BRC 27, 34, and 38. We will use apparent infrared excesses to look for candidate YSOs and to describe the properties of known YSOs in these regions. The center coordinates for each of our targets are:

- BRC 27: 07:03:59 -11:23:09
- BRC 34: 21:33:32 +58:04:33
- BRC 38: 21:40:42 +58:16:13

We will use primarily WISE data; the region around BRC 27 was already in the early public release, but we will obtain data for all 3 of our regions from the March 2012 WISE data release. We will use the WISE catalogs and the WISE color selection mechanism from Koenig et al. (2012), which is based on the Gutermuth et al. (2008, 2009) Spitzer color selection to select YSO candidates. These color cuts allow us to remove from consideration objects outside our galaxy such as external galaxies with elevated star forming rates and active galactic nuclei (AGN), shock emission blobs, and resolved structures based on established color restraints. We will then assemble data for our YSO candidates from as many other archival sources as possible, including data from existing literature, data derived from images of each candidate, and the generation of additional photometry data as needed.

Data we already plan to include are from the Two-Micron All-Sky Survey (2MASS), the Midcourse Space Experiment (MSX), and AKARI (literally "light" in Japanese, originally known as Astro-F). Some Isaac Newton Telescope (INT) Photometric H-Alpha Survey (IPHAS) data for BRC 34 and 38 were reported in Barentsen et al. (2011); if the IPHAS release that is predicted in Barentsen et al. for 2011 occurs in 2012, we will incorporate IPHAS data for our regions where possible.

Additionally, there are ~5x5 arcminute 4-band IRAC pointings in each of these regions obtained with Spitzer. The regions of IRAC 4-band coverage were analyzed for BRC 27 and 34 by a prior NITARP team (Johnson et al., 2012, Rebull et al. in prep; see also Chauhan et al. 2009 for BRC 27) and for BRC 38 by Choudhury et al. (2010) and Chauhan et al. (2009). For each of these 4-band regions, there are serendipitously obtained "flanking fields" of 2-band coverage with IRAC. We will use these serendipitously obtained data to aid in our assessment of YSO candidates. We will also include any Multiband Imaging Photometer for Spitzer (MIPS) data, or additional IRAC data in these regions, as appropriate. See Table 1 below for a list of the Spitzer imaging data we have identified from the Spitzer Heritage Archive (SHA) in our regions.

The Spitzer data will likely require us to re-reduce or at least redo the photometry for our targets of interest. If a re-reduction of the Spitzer data is needed, we will use MOPEX (Makovoz & Marleau 2005) to construct the mosaics. For the photometry, we will use the Aperture Photometry Tool (APT; Laher et al. 2012) found at www.aperturephotometry.org. Because the Spitzer data (both IRAC and MIPS) are of such different resolution (and sensitivity) than WISE, and because both Spitzer and WISE have varying resolution across their bandpasses, we expect that issues of spatial resolution will be prominent in our analysis and consequently in our classroom activities (see Section 4 below).

Through Co-I J. D. Armstrong, we will also obtain new ground-based optical photometry in the Sloan bands i and r using the 2-m Las Cumbres Observatory Global Telescope (LCOGT) on Haleakala. Ground based data will flesh out our data set on the shorter wavelength end, and help us identify star producing galaxies masquerading as YSOs. These data will need to be reduced and photometry performed on all relevant sources. Similar data were obtained for the 2011 team working on BRC 27 and 34; we will start by using these data, and obtain more as needed, including data for BRC 38. Co-I R. Laher reduced these data before, and will reduce any additional data we obtain. Photometry will again be obtained using APT.

We will collect all the photometry data in Excel spreadsheet form, where we can perform necessary calculations, such as flux density/magnitude conversions, and produce color-color and color-magnitude diagrams as well as spectral energy distributions (SEDs). We will use the shape of the objects in all available images, their colors and locations in color-magnitude and color-color diagrams, their projected location in space, and the shape of their SEDs to assess individual YSO candidates, following the procedure in, e.g., Johnson et al. (2012), Rebull et al. (2011; a 2010 NITARP team), and Guieu et al. (2010; a 2005-2007 NITARP team).

4. Education and Outreach

4.1 Introduction

Team C-WAYS is made up of a wide variety of adult and school age learners. Our adult learners include middle school, high school, community college, and informal educators. Our school age learners, therefore, will also represent a wide range of ages and abilities. Each sub team of educator and school age learners will spend time immersing themselves in general astronomy concepts and skills necessary to the success of C-WAYS research as appropriate for their age and ability. Some of these concepts and skills are:

- General properties of light and the electromagnetic spectrum with special emphasis on infrared
- Multi-wavelength astronomy with emphasis on wavelengths and image sources that we will utilize: IRAC, MIPS, 2MASS, MSX, AKARI , IPHAS and LCOGT
- Life cycle of stars with emphasis on Young Stellar Objects (YSOs)
- Infrared excess and its relation to YSOs
- Spatial resolution with particular emphasis on the relative spatial resolutions of WISE vs. Spitzer images
- Similarities and differences of WISE and Spitzer missions and why they were designed as they were
- Photometry methods and terms, particularly the use of MOPEX and APT
- Data manipulation and generation of graphics using EXCEL

With appropriate background schema in place, both adult and school age learners will experience authentic scientific research in a true collegial manner. Based on thorough Astronomical literature searches, journal articles relevant to our area of study will be read, analyzed and discussed. Data acquisition and analysis will take place before, during and after the CWAYS team's visit to Caltech in July. Communications between sub- teams will take place via regular teleconferences, videoconferences, extensive use of the Coolwiki, and email. A scientific and education poster will be created and presented by the CWAYS team at the 2013 AAS based on results obtained through this process.

Participation in NITARP will enrich every CWAYS learner with the experience of having done authentic research as part of a cross continental team. This experience will not only increase each learner's knowledge of astronomy and the research process, but will increase their interest and excitement level towards research opportunities. This knowledge, interest and excitement will be paid forward through formal outreach to education and community groups by all learners, as well as informally to adult and school age peers of all those involved.

4.2 Team Lincoln Way High School (P. Piper)

Teachers and students from several of the districts four schools (including the district's ROTC program) will be involved in this process through the district's new "distance learning" equipment. Student interest and commitment will be assessed through weekly sessions in which students will learn basic concepts and computer skills. A school page on the wiki will be created and used to share knowledge within this sub group and to reach out to other groups. Outreach will be coordinated with Educational Outreach colleagues at Yerkes Observatory and will include sessions at local, national and international workshops. Past presentations have included local school groups, Yerkes workshops, Illinois Science Teachers Association, and Global Hands-On Universe.

4.3 Team New Philadelphia High School (D. French)

New Philadelphia High School students will be participating in the NITARP research project as an extracurricular activity and may apply for the Ohio Flex Credit option. Students will be selected via an application process in March or April 2012. Students will participate in weekly research meetings to discuss background information, journal articles, and to work on data reduction and analysis. They will be responsible for keeping a science notebook for recording notes, comments, and for keeping applicable journal articles. Students will use the NITARP CoolWiki page to obtain additional background information and communicate with other team members. After the January 2013 AAS meeting, they will present their research to the New Philadelphia Board of Education as well as other venues and outreach activities.

4.4 Team Reedley College (L. Novatne)

A small group of college freshman and sophomores will meet weekly. For the first few weeks, the students will be instructed on the basics of star formation and stellar evolution. Once the students understand the basics, they will begin reading the appropriate journals and conduct web research for discussion. Once the data processing instruction has been completed, the students will work together and separately on the data analysis portion of the project. The weekly meetings will introduce the students to star formation mechanisms and stellar life cycle, spectral analysis, black body curves, and photometry. In the Fall of 2012, the weekly meetings will include the data processing and analysis.

4.5 Team Walter Payton College Prep High School (J. Barge)

Students from Walter Payton College Prep High School (WPCP) will participate in NITARP as part of WPCP's seminar program and will be selected through an application process in April 2012. They will meet weekly to develop their understanding of the content and skills needed to participate in this research opportunity. The NITARP CoolWiki site will be utilized for communication among themselves and among the other schools and scientists in the CWAYS network. Professional development outreach will given through the educational outreach network at Yerkes Observatory and local and national workshops, such as the Illinois Science Teacher Association and the National Science Teachers Association.

4.6 Team Soref Planetarium (R. Bonadurer)

With the assistance of a Milwaukee area high school or college astronomy instructor, qualified and interested student(s) will be selected to take part in the research portion of the NITARP experience. Presentations of the NITARP program and results will be shown at the Soref Planetarium at the Milwaukee Public Museum which will include dramatic full dome animations of star formation and 3D journeys to the Seagull and Elephant Trunks Nebula. Presentations will also be given at area schools, universities, and astronomy clubs.

4.7 LCOGT (J. D. Armstrong)

Through Co-I J. D. Armstrong, we will train team teachers and students in the remote use of the Faulkes Telescope North (FTN) on Haleakala. LCOGT.net, the company that owns and operates the FTN, is building an array of telescopes for research and educational use. Use of this remote telescope network will enrich both adult and student learners' understanding of ground based observation opportunities and capabilities. Once these participants are trained on these telescopes, they can request data from these telescopes to support future research endeavors. (We will be using data from the FTN to support our science research, as described above.)

5. Summary

In summary, this project will look for YSO candidates in BRC 27, 34 and 38 using infrared excess. We will discover new YSO candidates as well as rediscover previously-known YSOs; the properties of previously identified YSOs will be explored as well. The primary data sets will be newly released WISE data in conjunction with Spitzer Archival data. This project is being conducted with team members that represent a large cross-section of learning communities. Educator team members will bring in sub-teams from middle school, high school, community college and informal education settings to work with scientists.

6. References

Barentsen G., Vink J.S., Drew J. E., et al. 2011, MNRAS, 415, 103.

Beltrán M.T., Girart J.M., Estalella R., et al. 2002, ApJ, 573,1.

Beltrán M.T., Girart J.M., Estalella R., et al. 2004, A&A, 426, 941.

Beltrán M.T., Massi F., L´opez R., et al. 2009. A&A , 504, 1.

Chauhan N, Pandey A.K., Ogura K., et al. P.S., 2009, MNRAS, 396, 964.

Choudhury R., Mookerjea B., Bhatt, H.C. 2010, ApJ, 717, 2.

Connelley M.S., Reipurth B., Tokunaga A.T. 2007, AJ, 133, 4.

Getman K.V, Feigelson E.D., Garmire G. 2006, ApJ654, 316.

Gregorio-Hetem J., Montmerle T., Rodrigues C. V., et al. 2009, A&A, 2009, 506, 711.

Guieu, S.; Rebull, L.M.; Stauffer, J.R., et al. 2010, ApJ, 720, 46.

Gutermuth R.A., Myers, P.C., Megeath S.T, et al. 2008, ApJ, 674, 336.

Johnson C.H, Rebull L.M, Gibbs J. C. et al. 2012, AAS #219, 337.05.

Koenig X.P., Leisawitz D.T., Benford D.J, et al. 2012,ApJ, 744, 130.

Laher R., et al. 2012, PASP, submitted; http://spider.ipac.caltech.edu/staff/laher/apt/paper1.pdf

Makovoz D., Marleau F. R. 2005, PASP, 117, 1113.

Maoz, D., 2007, Astrophysics in a Nutshell (Princeton, NJ: Princeton University Press)

Nakano M., Sugitani K., Watanabe M., 2012, AJ, 143, 61.

Nisini B., Massi F., Vitali F., et al. 2001, A&A, 375.

Ogura K., Sugitani K. 1999, Proceedings of Star Formation, 381-382

Ogura K., Sugitani K., Pickles A. 2002, AJ, 123, 2597.

Pottasch, S. 1956, BAN, 13, 471.

Rebull, L.M., Koenig, S.P., Padgett, et al. 2011. ApJ. 196,4.

Rebull, L.M., Johnson, C.H., Hoette, V., et al. 2011, AJ, 142, 25

Rebull, L.M. et al. 2012, in preparation.

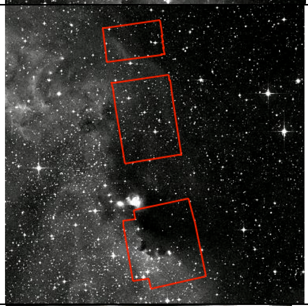
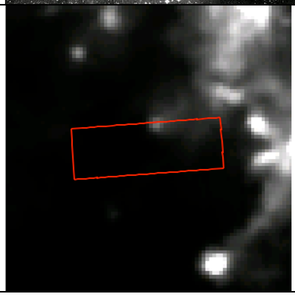
Reipurth B., Armond T., Raga A., et al. 2003, ApJ, 593.

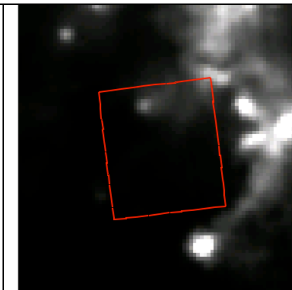
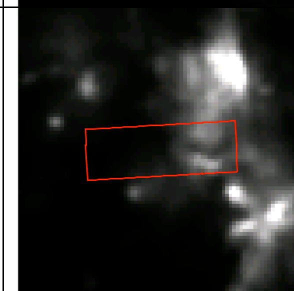
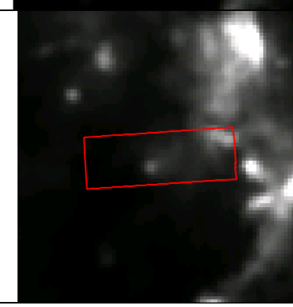
Saraceno P., Ceccarelli1 C., Clegg P., 1996, A&A, 315.

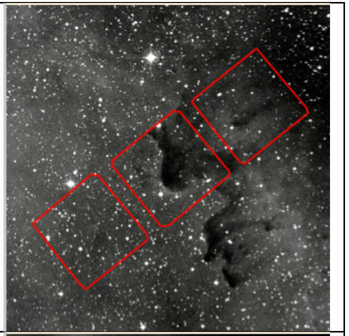
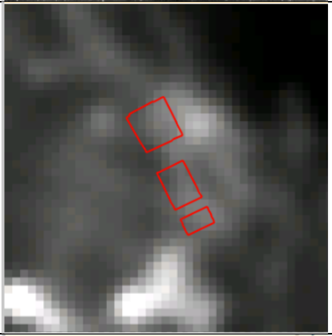
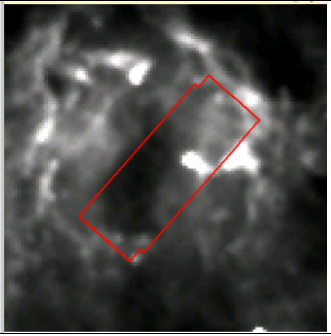
Soares J.B., Bica E., 2003, A&A, 404, 217.

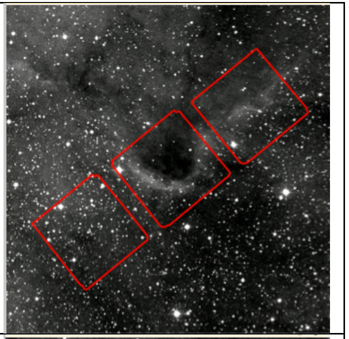
Soares J.B., Bica E., 2002, A&A, 388, 172.
Sugitani K., Fukui Y., Ogura K., 1991, ApJS, 77, 59.
Wang K., Wu Y., Ran L., Yu W., Miller M., 2009, A&A, 504, 369.
Werner, M.W.; Uchida, K.I.; Sellgren, K., et al, 2004, ApJS, 154, 1.
Wiramihardja S.D., Kogure T., Nakano M., Yoshida S., 1986, PASJ, 38, 395.
Wright E. L., Eisenhardt P. R.M., Mainzer, A. K., et al. 2010, AJ, 140, 1868.

Table 1.

Target Name	RA	DEC	Instrument/Mode	AORKEY	AOR Label	Wavelengths	Image
BRC 27	7h3m58.71s	-11d23m10.2s	IRAC Map	17512192	IRAC-brc27	3.6μm, 4.5μm, 5.8μm, 8μm	
BRC 27	7h3m58.71s	-11d23m10.2s	MIPS Phot	17512448	MIPSP-brc27	24μm, 70μm	
224.97388 GLIMPSE	7h7min16.17s	-11d30m59.8s	IRAC Map PC	38949120	224.97388-01.76750.20100511	3.6μm, 4.5μm	

225-02	7h6m28.5s	-11d38h47.5s	IRAC Map	14773760	IRAC-0001 – 225-02	3.6μm, 4.5μm, 5.8μm, 8μm		
224.4297 3 GLIMPSE	7h6m15.07s	-11d2m0.3s	IRAC Map PC	38973184	224.42973-01.76750.20 100511	3.6μm, 4.5μm		
224.7019 2 GLIMPSE	7h6m45.61s	-11d16m30.5s	IRAC Map PC	39074304	224.70192-01.76750.20 100511	3.6μm, 4.5μm		

BRC 34	21h33m32.0s	+58d04m30s	IRAC Map	6031616	IRACbrc34	3.6μm, 4.5μm, 5.8μm, 8μm	
BRC34	21h33m32.0s	+58d04m30s	MIPS Phot	6031872	MIPSPbrc34	24μm, 70μm	
IC1396	21h38m08.0s	+57d26m48s	MIPS Scan	4316416	IC1396_map	24μm, 70μm	

BRC 38	21h40m42.3s	+58d16m10s	IRAC Map	6032640	IRACbrc38	3.6μm, 4.5μm, 5.8μm, 8μm	
BRC 38	21h40m42.3s	+58d16m10s	MIPS Phot	6032896	MIPSPbrc38	24μm, 70μm