

WISE Young Stars in Cassiopeia and Ophiuchus

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Overview

In 2010, the WISE telescope spent 10 months completing an allsky survey in four different infrared wavelengths. Infrared light has a longer wavelength than visible light, so it can penetrate dust in outer space. Our atmosphere obscures most infrared light so the telescope was put in space.

The WISE telescope allows us to see regions in space that are visibly obscured by thick clouds of dust. These clouds not only hide stars, they also form them. Dust and debris from the clouds accumulate into a star that ejects excess material. This excess creates a disk around the star where planets can form.

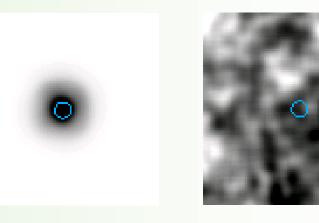
Our research focused on analyzing WISE data to look for Young Stellar Objects in planet-forming disks. Isabelle H. Jansen focused on a 100 square degrees around the Ophiuchus region, and Shaina Reisman focused on 40 square degrees around Cassiopeia.

Wide-Field Infrared Survey Explorer Telescope

The WISE was a 40 cm telescope launched on December 14th 2009. It surveyed the whole sky, taking photos at wavelengths 3.4 (W1), 4.6 (W2), 12 (W3), and 22 (W4) microns, well into the mid-infrared. With a resolution of 6 arcseconds, 10 times better than its predecessor IRAS, WISE took 8 or more photos of 99.9% of the sky. After its cryostat ran out of hydrogen ice, it continued to take photos in the W1 and W2 bands until January 2011.

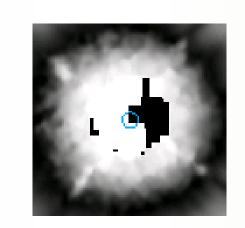
Method

Our first step was a database query to the WISE All Sky Catalog to find sources that had excess infrared-- sources with a brighter (lower) magnitude in W4 than in W1. This list of objects was manually checked against the database pictures to filter out the objects that had an excess but no source (edges of clouds or bright infrared stars offset from the center could fool the computer into thinking there was another star there). We also excluded images that had too much nebulosity or background, and images where the object was saturated.



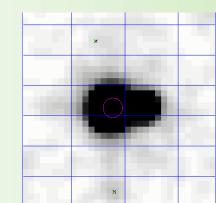
Artist conception of

the WISE telescope

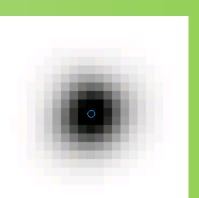


WISE images from right to left: W4, a valid candidate W4, nebulosity without a star W1, a saturated source

Using our filtered list of object candidates, we looked at the objects in the 2MASS database, where the higher resolution allowed us to view potential contaminant sources nearby (another star less than 15 arcseconds away could interfere with measurements). The higher resolution also allowed us to identify possible galaxies, which have the same infrared excess that young stars with disks do.



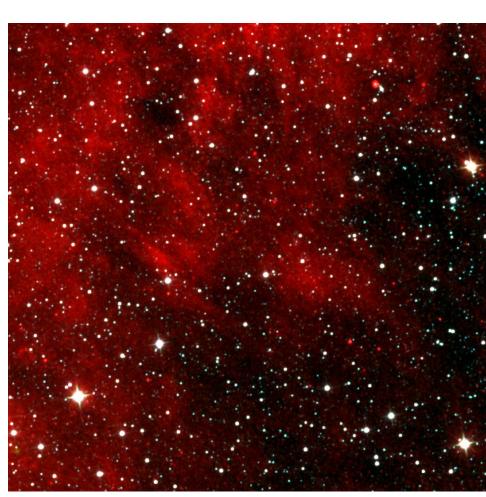
On left: 2MASS image of object J161706.81-281428.6, with a 30 arcsecond field of view. A companion is clearly seen, possibly a binary star. On right: same object seen in WISE, with the same field of view. There is no indication of a companion.



Having narrowed down our list, we graphed spectral energy distribution (SED) plots using the data from both WISE and 2MASS. We fitted a blackbody function to the 2MASS data, which allowed us to see better how much infrared excess the stars had. This excess represented another, cooler object in the same location as the blackbody star, which is generally a disk of dust surrounding the star.

We also searched the SIMBAD Astronomical Database to determine if our objects had been previously known. Some of them were known, but most of our objects turned out to be completely new! The final step will be to analyze the SEDs and compare them to the SEDs of known objects, which will allow us to identify what our sources represent.

Cassiopeia

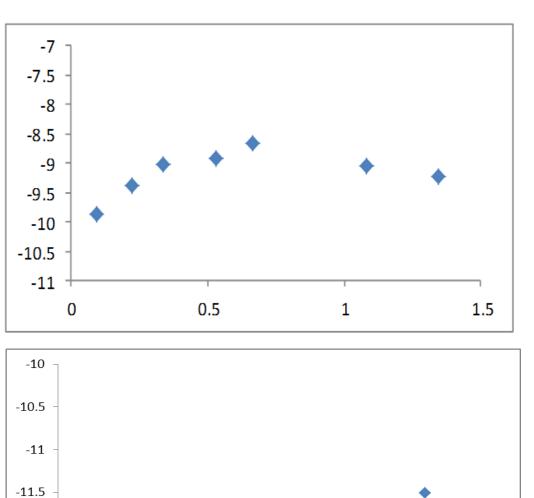


The Cassiopeia star-forming region is located between galactic latitude -5 and 15 and galactic longitude of 120 and 130. I performed a search on 40 square degrees, in

are spread far apart with the closest cloud approximately 180 parsecs away, and the farthest clouds located more than 2.8 kpc away (Kun, 2008, Handbook of Star-Forming Regions, Vol

stellar objects. Most studies used IRAS data, including one by Kerton & Brunt (2003, A&A, 1083), who created a catalogue of CO clouds.

My initial query returned 2060 objects, and after viewing the WISE images, I had 1024 viable candidate objects. From these objects, I discovered that 249 objects had some sort of references in SIMBAD, and 775 were completely unknown. Of the 249 known objects, 29 had no literature references. 72 more did not have any references to infrared astronomy. I



In the WISE image (near right), this object, a known galaxy, appears to be a point source, much like a young star, brighter in band four than the surrounding

The 2MASS image (lower right,) has some extension at 45 degree, but it may easily be overlooked. This image is 8% the area of the WISE image.

The SED (far right) shows an interesting curve, but nothing that will cause the object to be thrown out. A blackbody curve (red line) shows how the magnitudes fall off less rapidly than they should.

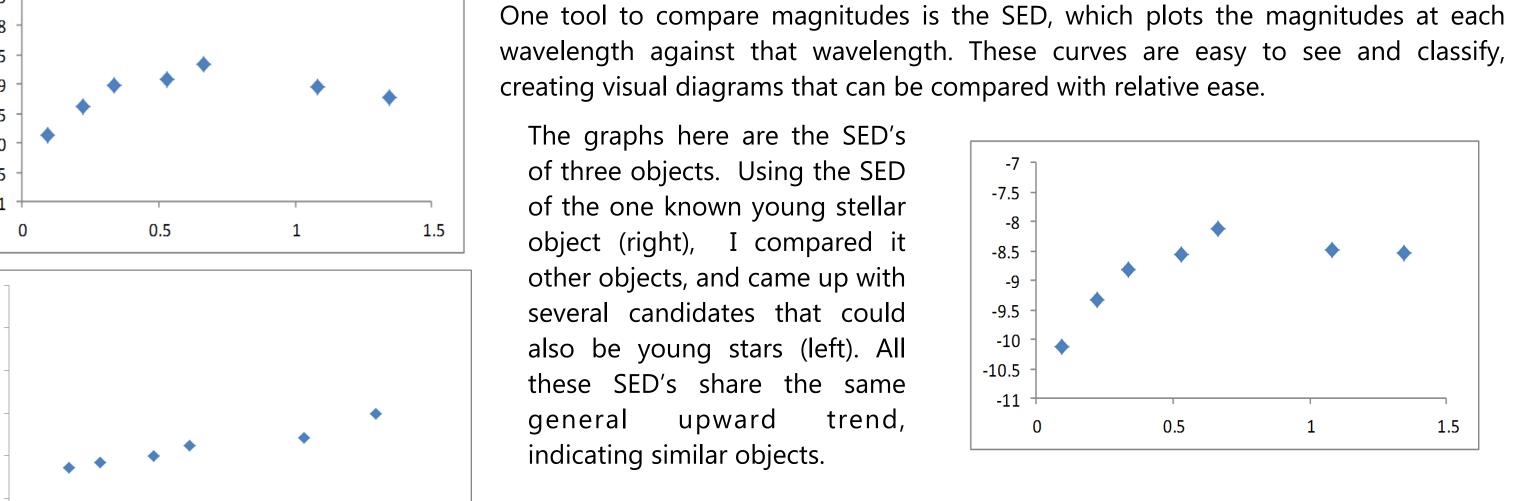
Comparing SEDs of unknown objects to the SED of a known galaxy helps determine if they are similar, but higher resolution is needed for confirmation.

the galactic longitude region 120-124 and galactic latitude -5 to 5. The star-forming regions in Cassiopeia

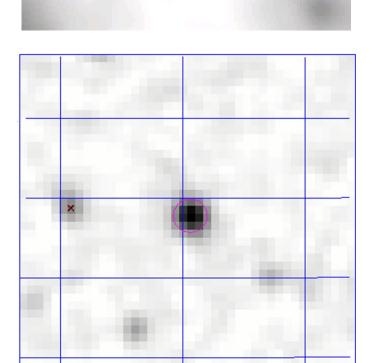
1, 240). This region has not been studied in great depth, and few if any focused on young

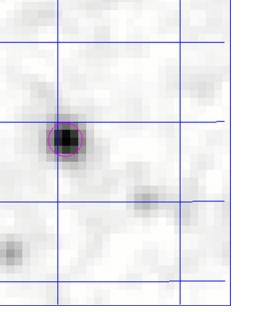
Finding Young Stars with Spectral Energy Distributions

found just one known young star, and one galaxy.



Discovering Galaxies





CircumstellarDisks.org

In 2005, Caer McCabe and Karl Stapelfeldt created the website circumstellardisks.org as an online catalog of known disks with images and references. Part of my project this summer has been to update this site, repair a Resolved disks section of the s few problems, and provide a couple of new features, such as a simple search function (in progress). I have also added a new category to the database, where candidate disks known from infrared photometry can be displayed for those interested in further research.

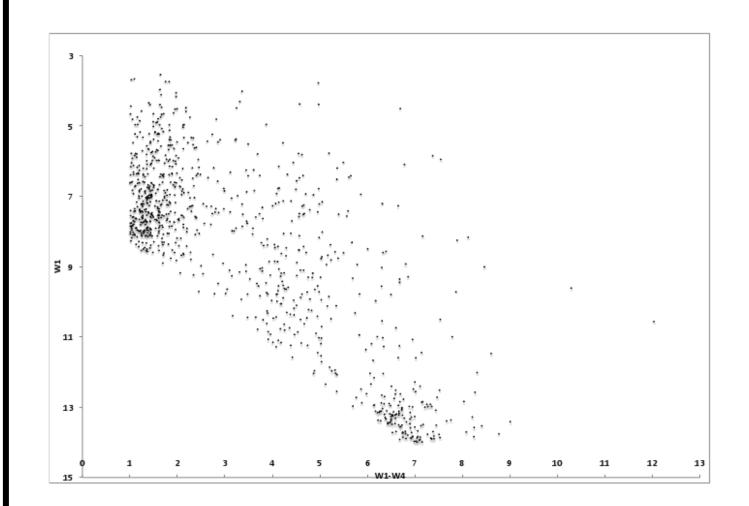


The region from right ascension 243 to 253, and declination -19.5 to -29.5 is a 100 square degree area centered on the ρ Ophiuchi cloud. This cloud is one of the closest to us, only about 130 pc away. Though the young stellar objects in the cloud itself have been studied extensively, with data from a variety of sources, including ROSAT,

Chandra, XMM-Newton X-ray, and Spitzer, a 100 square degree search has never been done before. WISE has the advantage over some of these instruments, by being able to discern

young stars with disks. A more recent paper on the topic of the young stellar objects, Wilking et al. (2008, *Handbook of Star-Forming Regions, Vol 2,* 351), mostly concentrated on the right ascension 245 to 250, declination -22.5 to -25.5 area.

The initial database search turned up 1571 objects, but the initial check in the WISE and 2MASS catalogs narrowed that down to 892. The search in SIMBAD showed that 242 of these objects had references about their infrared behavior, 124 objects were known, but had not had the possibility of a circumstellar disk explored, and 525 objects were completely unknown. Only one of the 892 objects was identified as a known galaxy.



Above: Color-Magnitude diagrams help separate the infrared excesses into different classes: the left-most cluster of objects are objects like normal stars with debris disks; the bottom-right cluster are objects like galaxies, and the objects in the middle are the young stellar objects with infrared excess. The straight lines on the edges of the graph are a result of the initial query, which specified limits on magnitudes as a sensitivity screening.

Right: The two graphs show the Spectral Energy Distribution (SED) plots of two objects as $log(\lambda)$ against $log(\lambda^*F(\lambda))$. The WISE magnitudes are the last four points, and the 2MASS data are the first three. Where appropriate, a blackbody function was fitted (blue line).

The top graph is a known Young Stellar Object Candidate from Evans et al., 2009.

The bottom graph is an extincted T Tau-type star, from Young et al., 1986, and is one of the two outliers in the colormagnitude graph to the

