IDentification of Young Stellar Objects in the Lagoon nebula (IDYL)

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ABSTRACT

The project's goal was to identify new young stellar objects (YSOs) in the Lagoon Nebula (M8; ~1250 pc). A collection of 67 bands, as published in 36 previous papers or surveys, was compiled into a catalog of ~3200 literature YSOs. We examined the color properties of these known YSOs in optical and infrared (IR) bands. The color characteristics of the known YSOs were used to identify new candidates based on the presence of IR excess, a result of dust surrounding YSOs, and ultraviolet (UV) excess from accretion shocks.

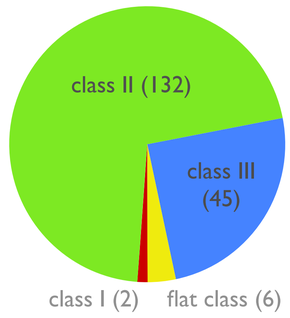
Literature YSOs, and the full M8 catalog, were plotted on numerous optical and IR color-color diagrams. The known YSOs informed our decisions as to what colors to use. The initial candidate YSO list was selected from sources that showed IR excess in both WISE and IRAC, or IR excess in IRAC and UV excess (u-r) in VPHAS. The candidate list was subsequently screened by examination of:

- source images (looking for source confusion and source detections missing photometry);
- spectral energy distributions (SEDs; looking for source mismatches across bands); and
- color-color and color-magnitude diagrams (optical and IR; looking for consistency with colors found for known YSOs).

We identified 185 new YSO candidates. Support provided for this work by the NASA/IPAC Teacher Archive Research Program (NITARP), which receives funding from the NASA ADP program.

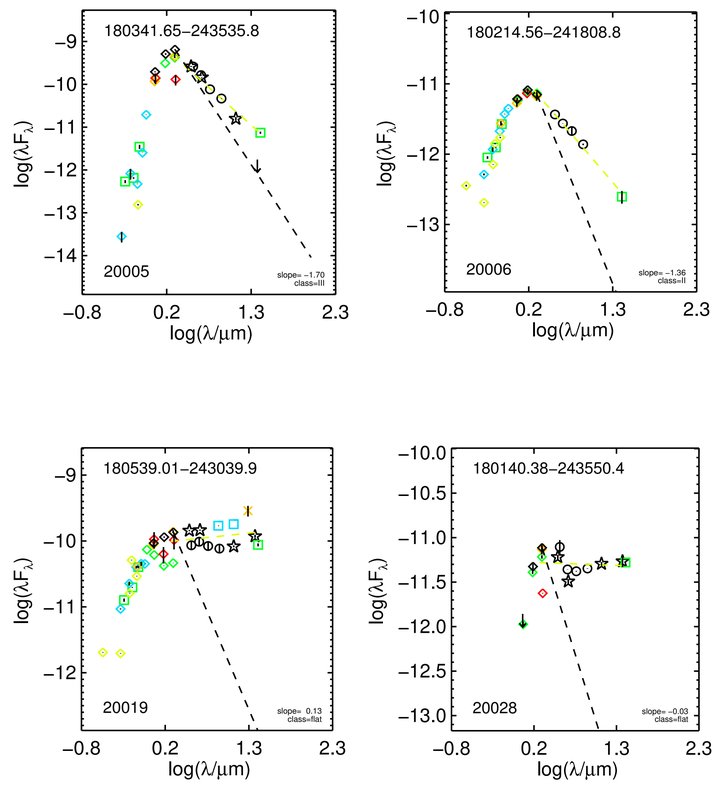
ANALYSIS

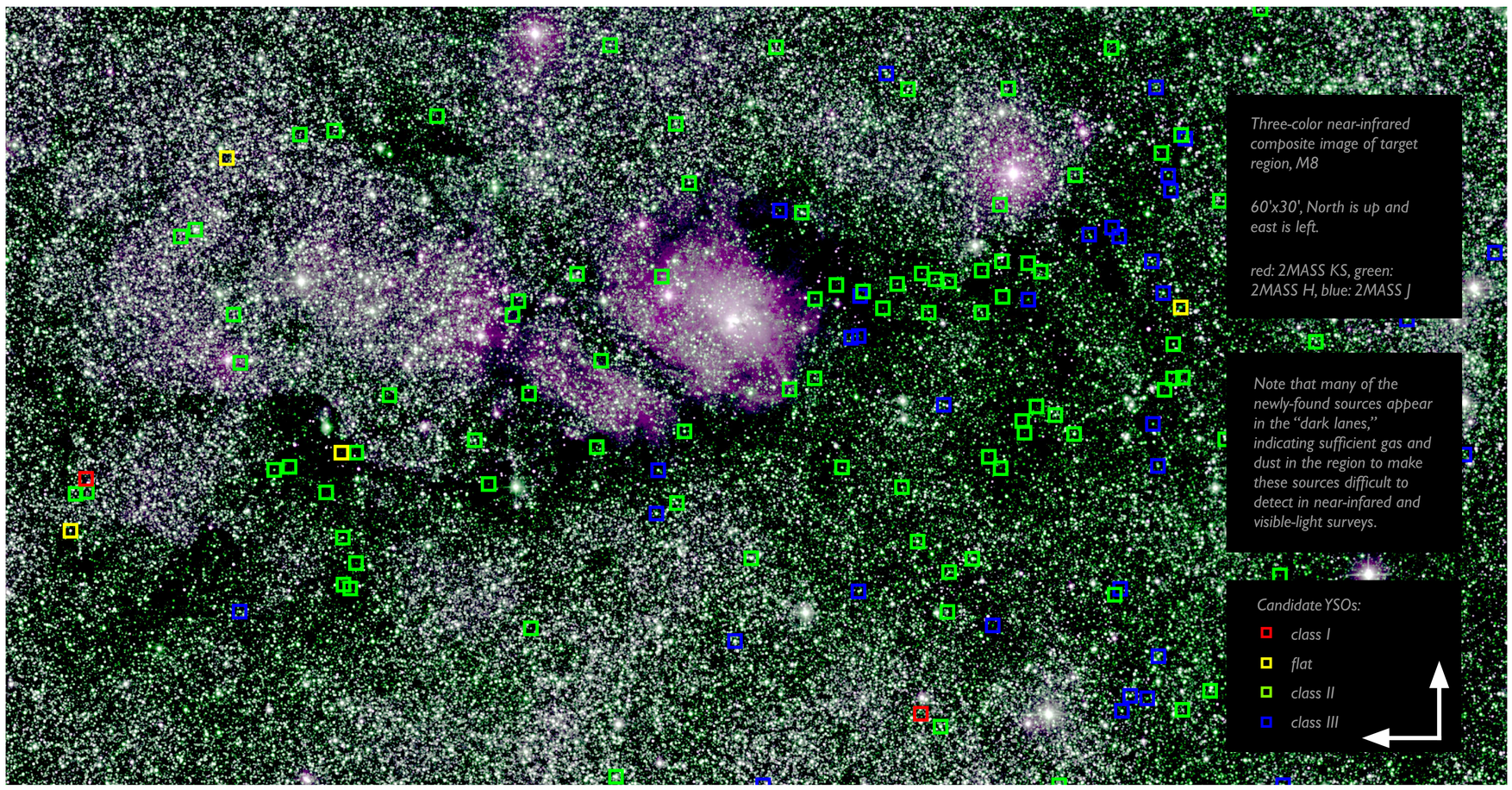
We screened each source by visually checking its images at IRAC 1,2,3,4 (3.6, 4.5, 5.8, 8.0 μm) MIPS 24μm, and WISE 1,2,3,4 (3.4, 4.6, 12, 22 μm), constructing an SED, and checking its position on optical and IR CMD and CCDs.



RESULTS

We find that 185 of our 188 candidates are probable YSOs that have not been previously identified (three are likely mismatches or confused sources). The majority of the new YSOs have disks of dust as shown by their detection at IR wavelengths, because that was our primary selection criteria. Some candidates are very embedded and reddened and are likely surrounded by a thick shell of gas and dust. Many (33%) of the new candidate YSOs lack an optical component. Our results provide a more complete inventory of YSOs in the region and contribute to a better understanding of the mass function of M8. Next steps: Obtain optical spectroscopy to confirm/refute the status of these objects as YSOs. This region was monitored by K2 and concurrently from the ground (with VST) in the optical; our collaborators (Cody & Venuti) are preparing light curves for targets that are sufficiently bright in the optical to have been detected by K2 and/or VST. We will explore the light curves of our candidate YSOs.





SOURCE SELECTION

The Lagoon nebula is in the galactic plane, very close to the galactic bulge, resulting in a very high surface density of sources. Assembling the catalog is challenging and requires more than just lights-out position matching; this is the main reason why we checked each source in several images.

We generated a catalog of ~610,000 sources in 67 bands from sources within 0.5 deg of 18:03:37.0 -24:23:12 as published in thirty-six previous papers or surveys. Among these are ~3200 literature YSOs that we vetted for source matching across bands and SED consistency.

We selected for objects with color characteristics consistent with either active accretion, or a dusty envelope or disk. We set these limits by looking at where the known YSOs in this region fell in a wide variety of color-color and color-mag spaces. We found that these three cuts separated the known YSOs from the rest of the sources in the region most efficiently.

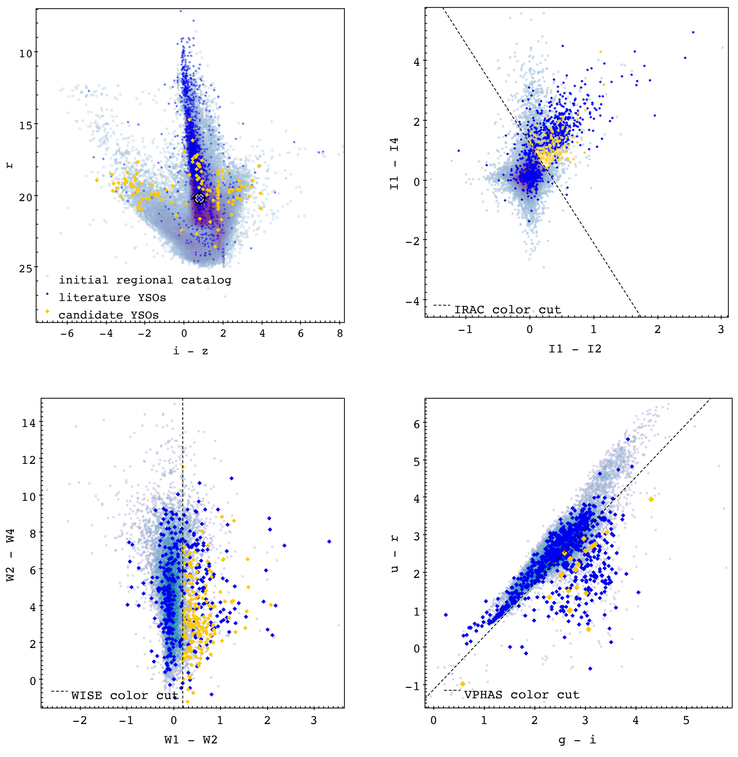
Cut 1: $(W1 - W2) > 0.18$

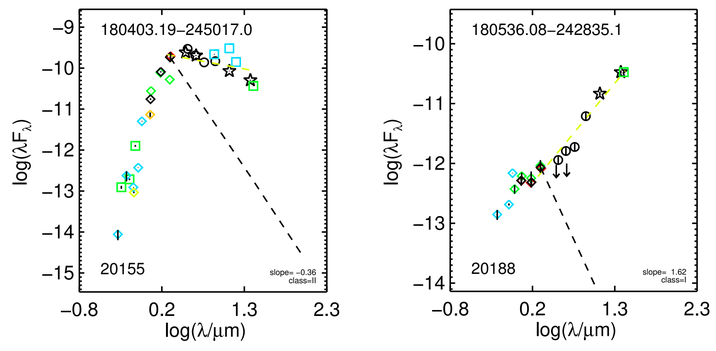
Cut 2: $(I1 - I2) > -3.34\,(I1 - I4) + 1.22$

Cut 3: $(u - r) > (g - i) - 1.11$

The initial candidate list consisted of sources that either met both conditions 1 and 2, OR conditions 1 and 3. Cut 1 plus cut 2 selects for dusty sources that show IR excess in both IRAC and WISE channels; 231 sources are in this group. Cut 1 plus cut 3 selects for dusty sources that also show UV excess in VPHAS bands; 28 sources are in this group.

Sixty-six of the remaining sources had Gaia distances > 1800 pc and were removed, leaving 188 candidates for manual screening.





Black dotted line is the Rayleigh-Jeans slope that extends from K band. This is where a dust-free star would be positioned.

The Chartreuse dashes are a line of best fit extending from K band through longer wavelengths (IRAC, WISE, MIPS24 and more). The slope of this line defines the YSO's class.

- misc Johnson & Cousins
- Gaia
- Bell
- PanSTARRS
- VVV
- VPHAS
- DENIS
- UKIDSS
- 2MASS
- IRAC (4)
- WISE (4)
- Akari
- MSX
- MIPS, PACS
- IRAS
- SCUBA

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