Spitzer Observations of IC2118

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Abstract: IC 2118, also known as the Witch Head Nebula, is a likely site of triggered star formation. In order to search for new young stellar objects (YSOs), we have observed this region in 7 mid- and far-infrared bands using the Spitzer Space Telescope and in 4 bands in the optical using the U. S. Naval Observatory 40-inch telescope. We find infrared excesses in 4 of the 6 previously-known T Tauri stars in our combined infrared maps, and we find 6 entirely new candidate YSOs, one of which may be an edge-on disk. Most of the YSOs seen in the infrared are Class II objects, and they are all in the "head" of the nebula, within the most massive molecular cloud of the region. This work will be published in Guieu et al. 2010 (Submitted).

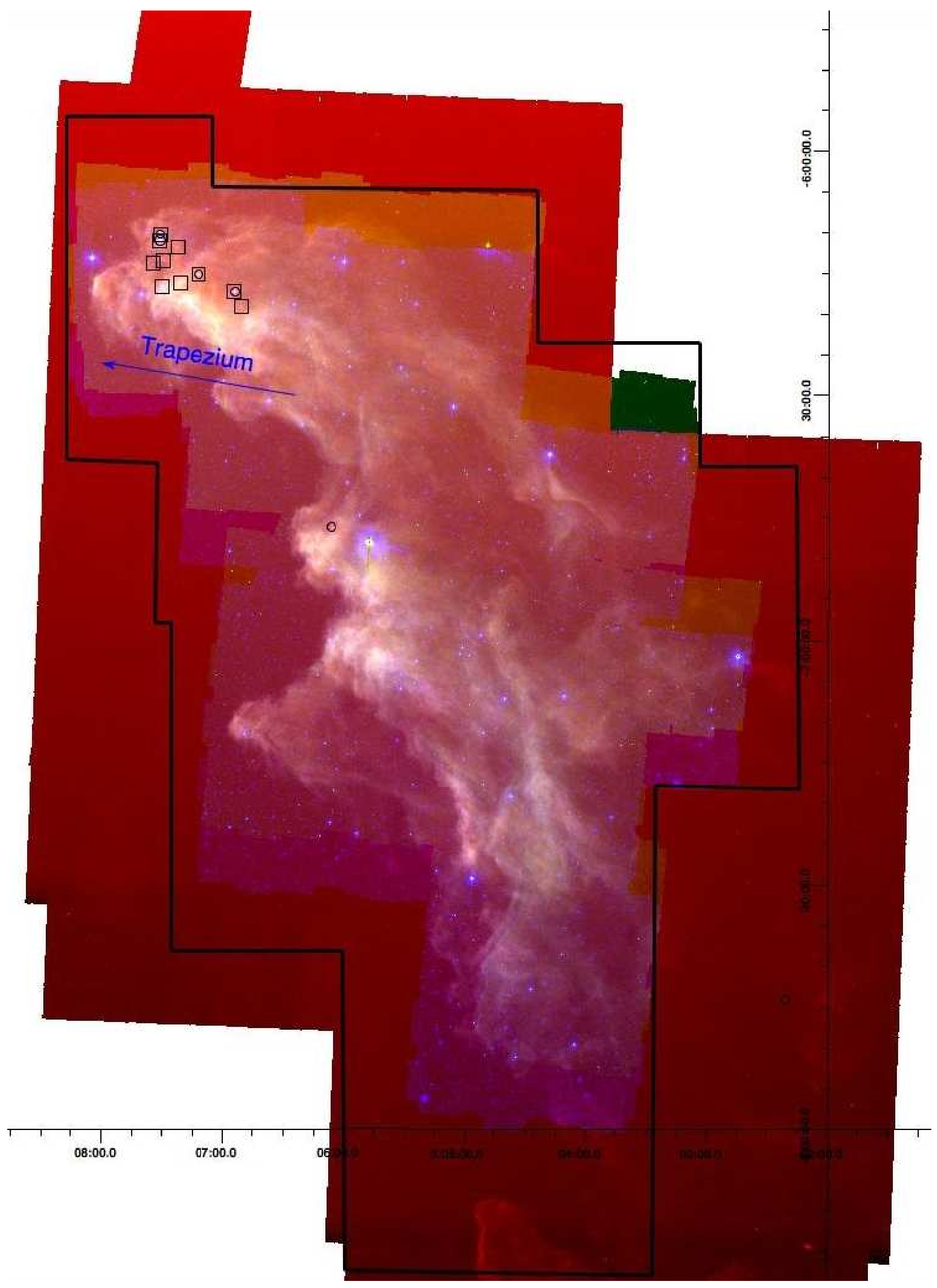

Figure 1: *Three-color view of IC 2118 with 3.6μm in blue, 8μm in green and 24μm in red. The black line is the outline of the optical survey. Squares are Spitzer selected YSO candidates and circles are previously known YSOs.*

Introduction:

Current theory tells us that in some regions, stars simply collapse under the influence of their own natal clouds' gravity, but in others, the process may be heavily influenced by external events.

IC 2118, the Witch Head Nebula is ∼5 degrees long; It is a good example of triggered star formation. The trigger candidates are Rigel, the Orion-Eridanus superbuble or the trapezium.

The specific distance to IC 2118 is controversial, varying from ∼200 pc to ∼400 pc (depending in part on what is the trigger).

We have conducted a large multi-wavelength photometric survey of IC 2118 (see table below) in order to search for new YSOs and put new constraints on triggered star formation and the distance and age of IC 2118.

Conducted Surveys

Instrument	Wavelengths	Area (deg ^{2})
USNO 40″	U, V, R_c, I_c	2.7
2MASS	JHK_s	
IRAC	3.6, 4.5, 5.8, 8μm	1.6
MIPS	24, 70, 160 μm	4

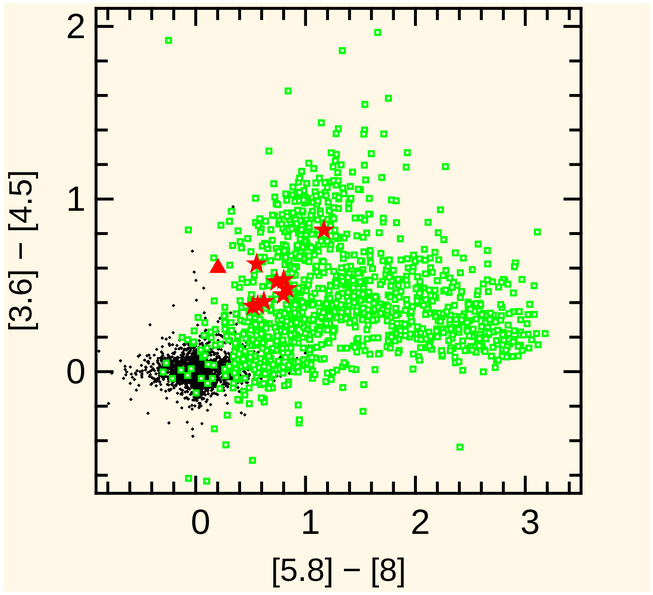

Figure 2: *IRAC color-color diagram. Green squares: background contaminants (galaxies, AGN). YSO candidates are plotted in red stars, the triangle is an edge-on disk candidate. The remaining sources are plotted in black.*

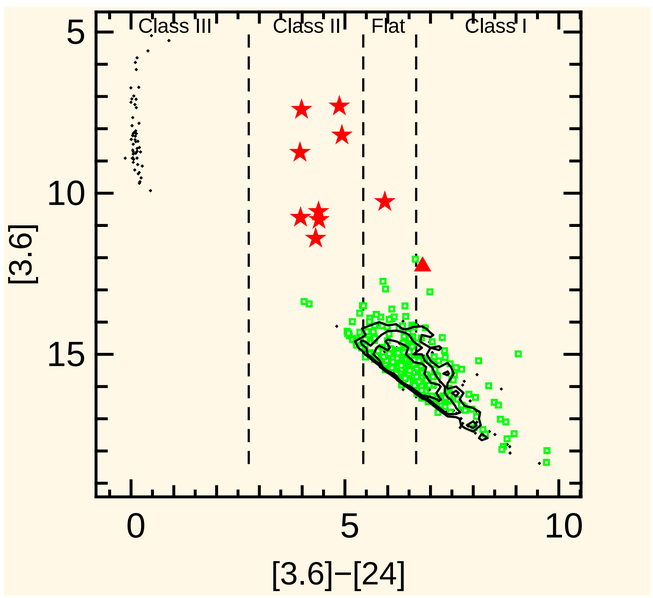

Figure 3: *IRAC-MIPS CMD, using the same symbols as in Figure 2. Additional black contours indicate the SWIRE sample distribution.*

Optical CMD:

We have used our USNO data to construct optical CMDs. Figure 4 shows a $V/V - Ic$ diagram; all YSOs except one (an edge-on disk candidate) appear younger than a 30 Myr model scaled to 210 pc. Most of the IRAC objects selected as contaminants appear as likely contaminants here as well.

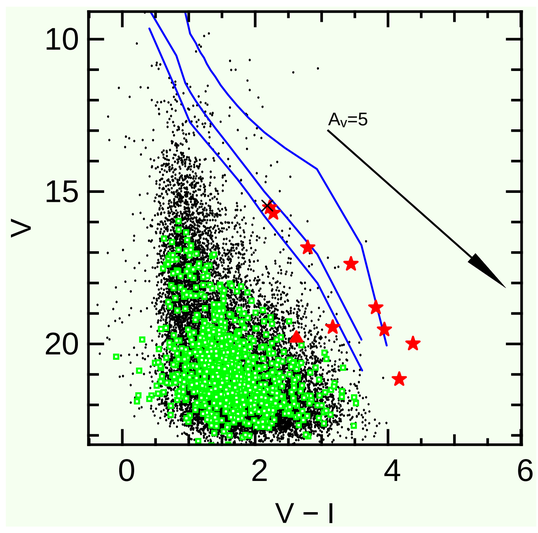

Figure 4: *Optical CMD. Symbols are the same as in Figure 2. Additional blue lines are tuned model isochrones from Siess et al. (2000, A&A 358,593) at 1, 10, and 30 Myr scaled to be at 210 pc.*

Spitzer YSOs:

We have selected 10 YSO candidates from their infrared excess and their magnitudes using a set of IRAC and MIPS color-color and color-magnitude diagrams. The location of these YSOs in the [3.6]-[4.5] *vs* [5.8]-[8] and the [3.6] *vs* [3.6]-[24] diagram is shown in Figure 2 and Figure 3 respectively, with the foreground and background contaminants included for comparison (galaxies and AGN, plotted in green). Using the SED of the 10 YSOs, we classified 8 as Class II, 1 as a Flat disk and 1 as an edge-on disk candidate.

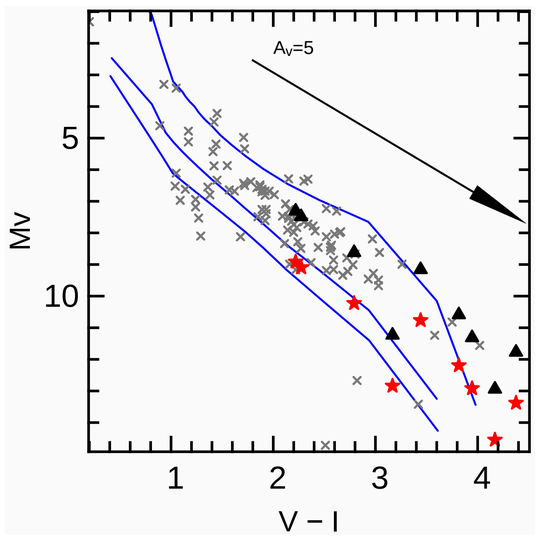

Figure 5: *Optical absolute CMD. Black triangles are our YSO candidates assuming a distance of 400 pc, red star symbols are those candidates assuming they are 210 pc away. The grey x are Taurus YSOs taken to be at 140 pc.*

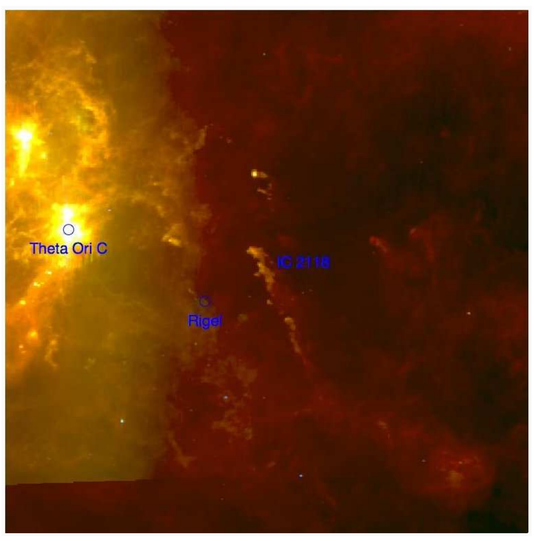

Figure 6: *3-color composite of IRAS data at 12, 25 and 100 μm. The region shown is ∼19° on a side centered on IC 2118. The position of Rigel and θ^1 Ori are indicated.*

Distance:

The distance of IC2118 is somewhat controversial. It varies from ∼210 to ∼400 pc, depending if the Orion-Eridanus superbubble or the Trapezium is the trigger. On Figure 5 we have plotted IC2118 YSOs in the $M_v/V - I_c$ diagram assuming the 2 distances and compared to Siess et al. (2000, A&A 358,593) models and Taurus young stars. We believe it is unlikely that IC2118 is significantly older than Taurus, suggesting that IC2118 is of order 400 pc distant. Also in the IRAS based 3-color composite in Figure 6, the morphology of IC2118 appears "wind-blown" by a source (maybe θ^1 Ori C) towards the ONC.