YOUNG, VERY LOW-MASS OBJECTS IN THE ELEPHANT TRUNK

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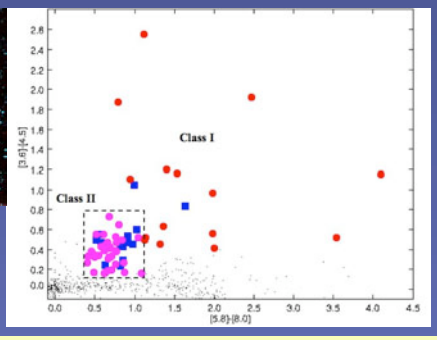
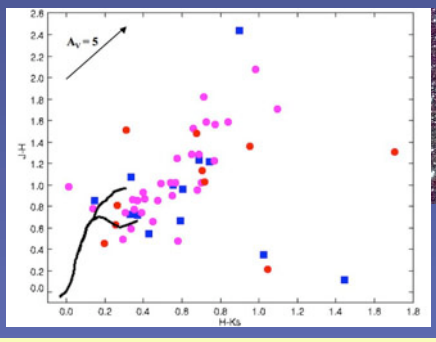
Abstract

The IC~1396 HII region is one of the best examples of star formation in dark cometary globules, triggered by the winds of the massive O6 star HD~206267 at its center. Here, we present the first results of a survey for very low-mass objects in the IC~1396A globule, also known as *the Elephant Trunk Nebula*. Our *Riz*, Hα and *JHKs* data are combined with the IRAC/Spitzer photometry from Morales-Calderón et al. (in press) to select candidate members of the region. Our objects have magnitudes between 14<I<20, corresponding to masses down to about 40~M_J in the areas of low extinction. They are the first substellar candidates identified so far in this region.

The infrared view

Spitzer view of IC1396A



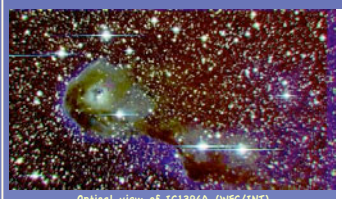


2MASS view of IC1396A

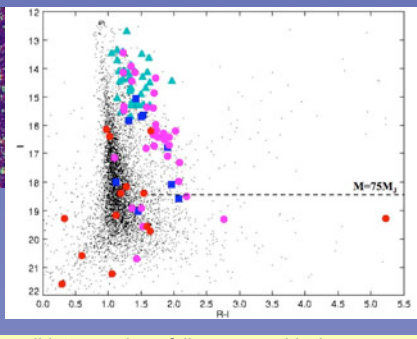
Left panel: Candidate young stellar objects are selected from *Spitzer*/IRAC 3.6, 4.5, 5.8 and 8.0 μm photometry. Class I and class II (red and magenta circles) sources occupy two distinct locii in a ([3.6]-[4.5], [5.0]-[8.0]) colour-colour diagram, clearly separated from sources with bare stellar photospheres (class III and field stars). The blue squares are the IC1396A candidate members from a mid-infrared variability study by Morales-Calderón et al. (2009, ApJ, in press). Shown are only objects with optical and near-infrared counterparts from our WFC/INT and OMEGA2000/CAHA 3.5m survey.

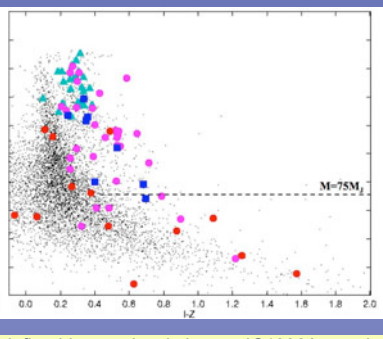
Right panel: Our candidate class I and II sources have very different values of extinction ($0<A_V<15$), as shown in the (*J-H, H-Ks*) colour-colour diagram by comparison with the colours of field dwarfs and giants from Bessell & Brett (1988, PASP 100, 1134; black solid lines). Some of the objects display an excess already at 2.2 μm, indicating large amounts of sorrounding dust.

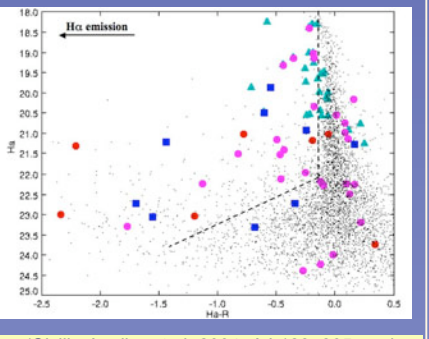
The optical view



Optical view of IC1396A (WFC/INT)



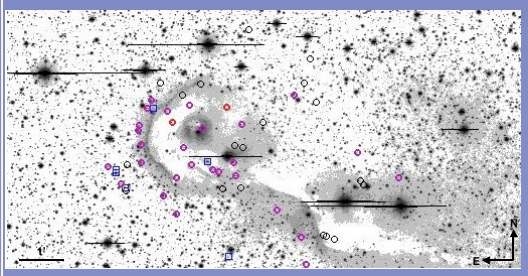


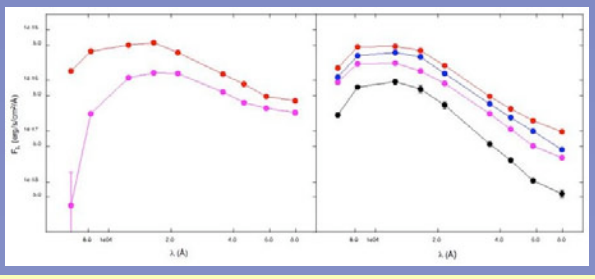


Left and central panel: Most of our candidate members follow an empirical sequence defined by previously known IC1396A members (Sicilia-Aguilar et al. 2004, AJ 128, 805; and 2005, AJ 130, 188; cyan triangles) in a (*I, R-I*) and a (*I, I-z*) colour-magnitude diagram. Some sources lie out of this sequence, and hence their membership status is more dubious, although some of them could be YSOs seen in scattered light. A few of our objects could be substellar; if confirmed, they would be the first brown dwarfs identified so far in this region.

Right panel: The Hα-*R* colour is an indicator of moderate-to-strong Hα emission at the CTTS level, usually related to accretion. Many of our candidates show Hα-*R* colours clearly bluer than the field objects. This provides a further youth indicator and suggests that these objects are accreting from their disks and/or envelopes.

Towards membership confirmation





Left panel: The spatial location of most of our candidates further supports membership to the dark globule: Most of the *Spitzer*-selected sources whose optical colours are consistent with membership to IC1396A (red and magenta circles for candidate class I and II objects, respectively) are located within the globule, or in the area recently evaporated by the winds from the nearby O-star HD 206267 to the East (not seen in the image). The blue squares indicate the positions of the objects selected by Morales-Calderón et al. (2009), and the black circles, the rest of our sources for which membership is more dubious.

Right panel: Examples of SEDs for some of our objects: Two candidate class I sources (left), displaying large mid-infrared excess suggestive of the presence of a disk and an envelope; and four candidate class II sources (right), where the envelope has almost completely evaporated and the dust is present mainly in the form of a circum(sub)stellar disk.

We have been allocated time to perform optical and near-infrared spectroscopy of our candidates with OSIRIS/GTC and NICS/TNG next summer. The spectra will allow us to derive spectral types for our objects, to measure surface gravities and to look for further youth indications such as emission lines related to accretion and mass loss. They will also help to elucidate the causes of the mid-infrared variability observed in some of the sources.