EXPLORING THE LOW-MASS END OF THE ELEPHANT TRUNK

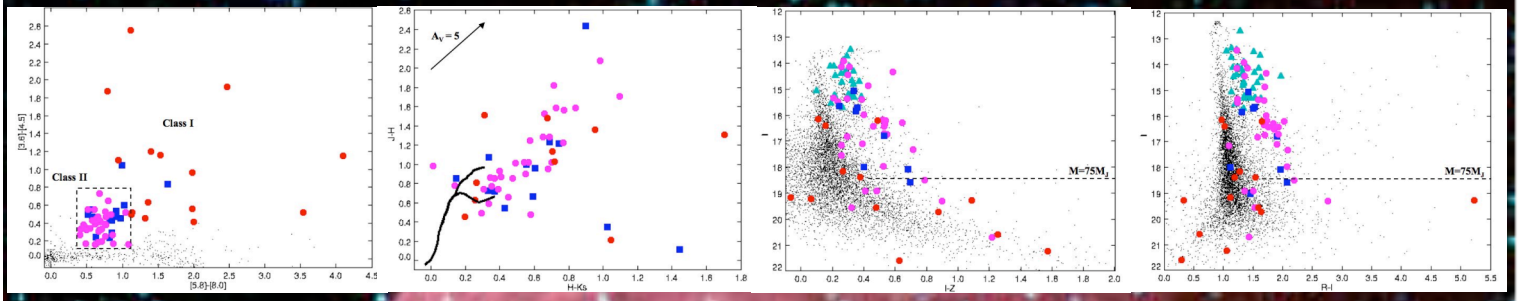
B. López Martí (1), M. Morales-Calderón (1,2), D. Barrado y Navascués (1), P. Riviere (1), A. Bayo (1) & S. Hodgkin (3)

(1) LAEX-CAB (INTA-CSIC), Madrid, Spain; (2) Spitzer Science Centre, Pasadena, CA, USA; (3) IoA Cambridge, Cambridge, UK

Abstract

The IC1396 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 low-mass objects in the IC1396A globule, also known as *the Elephant Trunk Nebula* (d~750 pc, age≤1 Myr). Our optical and near-infrared photometry is combined with the IRAC/*Spitzer* data from Morales-Calderón et al. (2009) 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. To confirm youth and membership, we have started an optical and near-infrared spectroscopic survey of our objects.

Candidate selection

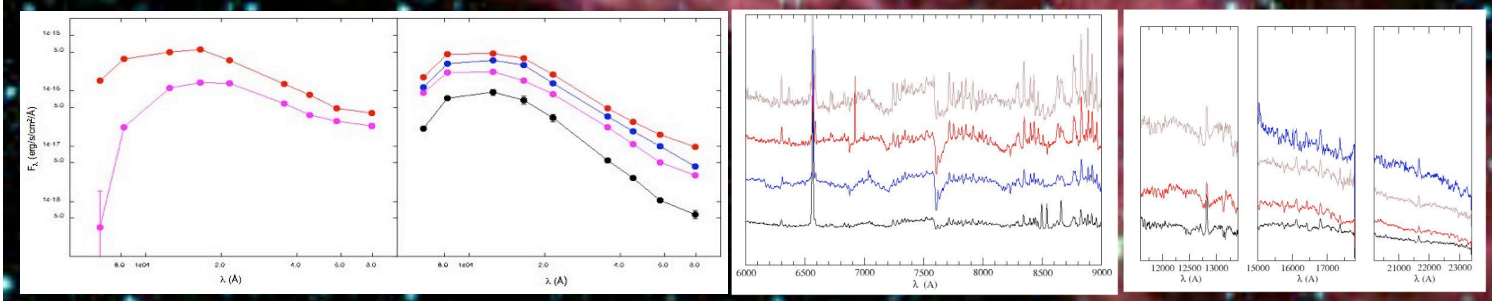


Candidate young stellar objects are selected from *Spitzer*/IRAC 3.6, 4.5, 5.8 and 8.0 μm photometry (left panel). Class I and class II (red and magenta circles) sources occupy two distinct locii in a ([3.6]-[4.5], [5.0]-[8.0]) colour-colour diagram, clearly separated from sources with bare stellar photospheres (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 702, 1507). Shown are only objects with optical and near-infrared counterparts from our WFC/INT and OMEGA2000/CAHA 3.5m survey.

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 (central left panel) 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.

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 (right panels). 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.

Towards membership confirmation



The left panel shows some examples SEDs of our objects: two candidate class I sources (left), and four candidate class II sources (right). The curve shapes are as expected for YSOs. The SEDs show different amounts of infrared excess, consistent with progressive clearing of the envelope and the (inner) circumstellar disk.

This summer we have started two spectroscopic campaigns to confirm the nature of our candidates. These data are currently being reduced. The central panel shows the very first optical medium-resolution spectra observed with OSIRIS/GTC, and the right panel some example near-infrared spectra taken with NICS/TNG. The objects are clearly late-type stars. The spectra confirm the presence of Hα emission and other emission lines (CaII, [OI], [SII], Paβ, Brγ) related to accretion and mass loss.

The triggered formation picture

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 shown 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.The fact that the less evolved objects are located in the most extincted (i.e. dusty) areas suggests a sequential formation process, consistent with the picture of triggered star formation by the winds of the massive star.