Characterization of the least luminous proto brown dwarf candidate

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1. Introduction

Brown Dwarfs (BDs) evolve very rapidly during the first million years. Their formation mechanism (or mechanisms) can be investigated by studying their properties when they are very young and deeply embedded in the parental cloud, what we call the proto-brown dwarf (proto-BD) phase. Using data collected by the Spitzer Space Telescope, several groups have detected the so-called Very Low Luminous Objects (VeLLOs), which are deeply embedded objects with internal luminosities below 0.1 $L_{\odot}$ (e.g. Young et al. 2004, Dunham et al. 2008, Lee et al. 2009). These VeLLOs are the best candidates known so far to be proto-BDs, although their nature is still not clear since there is not a systematic and detailed study of their properties

2. A proto-BD candidate in Taurus: J041757

During the last three years, our team was involved in a project to search for proto-BDs. As a result we have isolated a very promising candidate in the dark cloud B213 in Taurus: J041757 (Barrado et al. 2009).

J041757 is a Class 0/I substellar object according to color-color and color-mag Spitzer diagrams. Our JHK-band observations showed 3 possible counterparts (marked as A, B and C) at the position of the Spitzer detection (see Fig. 1a). The Spitzer data show that source 'B' is the near-IR counterpart. The CSO (350 µm) observations have revealed extended emission at the Spitzer position of the source, which can be interpreted as a dusty envelope around the proto-BD candidate (see Fig 1, left). The SED of J041757 is displayed in the middle panel of Fig. 1. It shows a positive slope between 3 and 70 µm which is typical of embedded objects. The integration of the SED provides an estimation of the luminosity of the source, 0.003 $L_{\odot}$ (see Fig. 1, right), which is the smallest reported so far for a VeLLO.

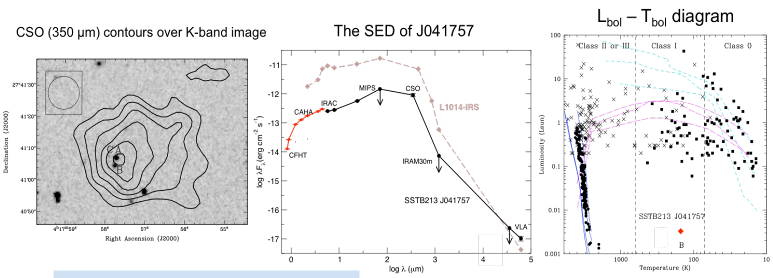

Figure 1: **Left:** K-band image of the target, which is resolved into three sources, component 'B' being the proto-BD candidate. The overplotted contours correspond to the CSO 350 µm observations. We detect extended emission around the source which we interpret as a dusty envelope. The angular size is 30" of diameter, that is, 4200 AU at the distance of the source. **Middle:** The SED of our proto-BD candidate (black line). For comparison, we have included the SED of the VeLLO L1014-IRS, another proto-BD candidate but with a higher luminosity. **Right:** the position of the proto-BD candidate in the Lbol–Tbol diagram, displaying the lowest luminosity of all known Very Low Luminosity Objects (VeLLOs).

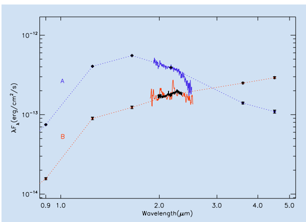

Figure 2 : VLT/ISAAC K-band spectra of components A (blue) and B (red). For comparison, we have overplotted the spectrum of the late-type protostar IRAS 04489+3042 (black line, Prato et al. 2009)

We have an on-going program to characterize J041757B spectroscopically. A preliminary result is shown in Fig. 2, where we display VLT/ISAAC near-IR K-band spectra of the source. The flat continuum is consistent with a young source surrounded by dust, and not with the photosphere of a background object. A more detailed analysis will be presented in a future publication.

3. SED modeling: the need for Herschel

In order to characterize the system, we have modeled the SED using a 3D multi-wavelength Monte-Carlo radiative transfer model (Stamatellos et al. 2004). The fits are obtained for 'B' being a low-luminosity object with a temperature of 1800 K surrounded by a disk. In the case of the envelope, we have assumed is heated internally by source 'B' and externally by the interstellar radiation field (ISRF). In order to cover the reasonable ranges of density and temperature allowed by our data, we have performed two types of fits varying the value of the interstellar radiation field (ISFR).

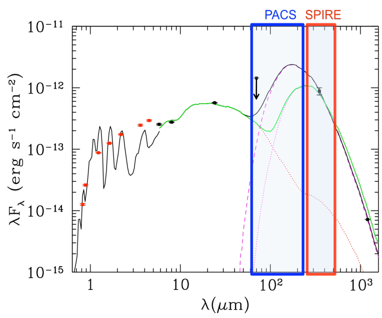

Figure 3: Our fit to the SED. The black and green solid lines represent two models with different interstellar radiation fields (ISRF). Herschel photometry is needed to break the degeneracy between theoretical models for the envelope and to constrain the main disc properties.

The results of our modeling are displayed in Fig. 3 and, although we can fit most of the data points, there are still some difficulties to characterize our object: the CSO 350 µm observations show extended emission, but the final size and shape depend on the reduction procedure (Palau et al. 2010), which translates into additional uncertainties when modeling the radial profile. Moreover, current observations are not enough to break the degeneracy of the models (green and black lines in Fig. 3). Observations between 70 and 300 µm are needed to estimate the temperature (and therefore, the mass) of the envelope and to better characterize the source and improve our modeling. All these problems can be solved by Herschel, which is the key facility to characterize this unique source.