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CHARACTERIZING THE EMBEDDED YOUNG STELLAR OBJECTS IN THE GALACTIC STAR-FORMING REGION IRAS 18236-1205

R. Retes,[1] A. Luna,[1] D. Mayya,[1] and L. Carrasco[1]

RESUMEN

Presentamos un estudio multibanda de candidatos a objetos jóvenes estelares (YSOs) embebidos en la nube molecular galáctica asociada con la fuente IRAS 18236-1205. Para identificar y clasificar a los YSOs embebidos en la nube molecular se usan los datos de 2MASS, Spitzer/IRAC, Spitzer/MIPS a 24 μm y gas molecular ^{13}CO(J=1-0). Se encuentran dos regiones con formación estelar activa, una localizada en la región central de la nube molecular asociada con la posición de la fuente IRAS y otra al Norte-Oeste de la fuente IRAS. Estas regiones están asociadas a su vez con nubes infrarrojas oscuras (IRDCs) y muestran una fenomenología que está de acuerdo con la fase temprana denominada "Hot Molecular Core", del proceso de la formación estelar de alta masa.

ABSTRACT

In this work, we carry out a multi-wavelength study of a sample of candidates to embedded young stellar objects (YSOs) in the galactic molecular cloud associated to IRAS 18236-1205 source. We used the Spitzer/MIPS 24 μm image to identify candidates to embedded YSOs in the molecular cloud defined by ^{13}CO(J=1-0) intensity maps, and compiled/carried out photometry of these sources in 2MASS, IRAC and MIPS bands. We defined two active star-forming sites in the molecular cloud: one at the location of the IRAS source, and other to the North-West of the IRAS source both associated to infrared dark couds (IRDCs). These regions shows a phenomenology according to the "Hot Molecular Core" early phase of the high mass star-formation scenario.

Key Words: ISM: clouds — stars: formation — stars: pre-main sequence

1. THE MOLECULAR CLOUD ASSOCIATED TO IRAS 18236-1205

The IRAS 18236-1205 source has typical IRAS colors of UCHII regions (Wood & Churchwell 1989), also detections of the OH and H_2O maser emission (Walsh et al. 2003), and of the high density tracer CS(J=2$\rightarrow$1) emission (Bronfman et al. 1996). These features make it a good candidate of massive star formation region.

We selected and defined the molecular cloud (Retes et al. 2009) towards IRAS 18236-1205 source using the ^{13}CO data of the Galactic Ring Survey (Jackson et al. 2006). Calculation of the N(^{13}CO) is obtained by standar methods (Tools of Radio Astronomy). We computed the N(H_2) = 4.8×10^{22} cm^{-2}, and an estimation of $A_V \gtrsim 30$ mag for the molecular component in the visual line towards the molecular cloud. We also estimated it cloud Virial mass, $M_{\rm vir} \approx 1.0 \times 10^5\ M_\odot$.

[1]Instituto Nacional de Astrofísica, Óptica y Electrónica, Apdo. Postal 51 y 216, Puebla, Mexico (rretes, aluna, ydm, carrasco@inaoep.mx).

2. THE SELECTION OF THE EMBEDDED YOUNG STELLAR OBJECTS

We have defined a sample of 126 sources candidates to protostars and YSOs embedded into the molecular region with the following characteristics: bright FIR (from MIPS 24 μm data) point-like sources within 40σ contour of the integrated ^{13}CO molecular gas. All sources have a counterpart in the spectral range 3.6 μm to 24.0 μm, and 85% of the sources satisfied [3.6]-[8.0] > 0.6, a photometric criterion to identify candidates to YSOs with IR excess (Whitney et al. 2008).

3. IDENTIFICATION AND CLASSIFICATION OF YSOS

In order to classified the sample of candidates to YSOs, we have constructed their spectral energy distribution (SED). The evolutive star formation stage of YSOs candidates was following the Lada's criterion (Lada 1987), derived of the spectral index in the spectral range 3.6 μm to 24.0 μm.

We check out the likely evolutive stages of the YSOs using the [3.6]-[5.8] vs. [8.0]-[24] diagram (Robitaille et al. 2006). This diagnostic diagram has three well defined regions for objects in different evolutionary stages. We obtained 75% of class I objects (earliest YSOs; protostars), the 40% of the class II objects (disk-like YSOs), and the 30% of the class III objects (latest YSOs) are in the correspondent regions of the diagram. There are a likely effect of contamination on the [4.5], [5.8] and [8.0] IRAC bands that introduce a dispersion in the distribution due to interstellar emission by PAHs, which contribute important in these bands at star-forming regions.

In order to obtain a physical characterization for the YSOs, we have obtained physical parameters for the objects using a fitting tool SED models (Robitaille et al. 2006) and selected the best ten models for the fit the SED model to data of each object. We have found that the class I and II (likely youngest YSOs) have the highest accretion rates while the evolved class III have null presence of accretion.

4. DISCUSSION AND CONCLUSIONS

4.1. *Spatial distribution of YSOs*

From the spatial distribution of the YSOs we noted that (a) the class I objects and class II are associated with the highest column densities traced by the molecular gas, and (b) the class III objects are uniformly distributed over the molecular cloud. The distribution of the YSOs suggest a two different young population, evolved objects (CIII) associated to the low dense regions, where they have consumed the molecular gas in their formation process, and removed the molecular remanent material close to them, and a youngest population (CI/II) associated to dense regions which are coexisting with the IRDCs, where they have a reservory of material for their final formation.

4.2. *The YSOs associated to the central molecular region*

We found four sources associated to the central molecular region towards the IRAS source (within 1 arcmin), two of them have typical characteristic class I SED (protostar), one object has a class I/II SED, and other has a class II SED. From the physical parameters obtained using fitted SED models, we noted that the class I objects have highest accretion rates which is a feature of their earlier phase evolutive. These objects are associated with the brightest sources at 24 μm image, and could be the source of an outflow, which is suggested by the extended brighter emission at [4.5] IRAC band (EGO) and their association to methanol maser emission reported by Walsh et al. (2003) and Cyganowski et al. (2009). Therefore they are likely in earliest evolution stage of star formation process, and are excellent candidates to high mass star precursors. These objects shows a likely scenario for "Hot Molecular Core" phase, an early evolutive phase in the high mass star-forming process (Garay & Lizano 1999; Kurtz 2000; Churchwell 2002).

4.3. *The YSOs associated to NW molecular region*

We have found three YSOs associated to NW dense molecular subregion which is also associated to an IRDC; one of them, has typical class I SED, last two objects are class II. From the physical parameters obtained from the SED fit models, we noted that one class II and the class I objects have a moderate-high accretion rates. These objects are associated with brighter sources at 24 μm image and with a dense core at 1.2 mm continumm emission (Faúndez et al. 2004; Rathborne et al. 2006), and both are associated to "green fuzzy" objects in the 3-color IRAC/Spitzer image. Also these objects have an outflow associated by detection via HCO^+(1-0), HCN(1-0) and $C^{18}O$(2-1) by López-Sepulcre et al. (2010) and detection at SiO (2-1) and (3-2) emission line by López-Sepulcre et al. (2011), confirming their early evolutionary stage.

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