A massive and dense core in an early stage of evolution

***Yanett Contreras*[1,2], *Guido Garay*[1] and *Diego Mardones*[1]**

[1]*Department of Astronomy, Universidad de Chile,*[2] *Max-Planck-Institut für Radioastronomie*

Introduction

G305.136+0.068 is a dust core with no MSX or IRAS counterparts (see Fig.1), indicating it has a low dust temperature (< 16 K; Garay et al. 2004). We present here new observations made in order to investigate the physical conditions and kinematics of this cold core and its stellar content.

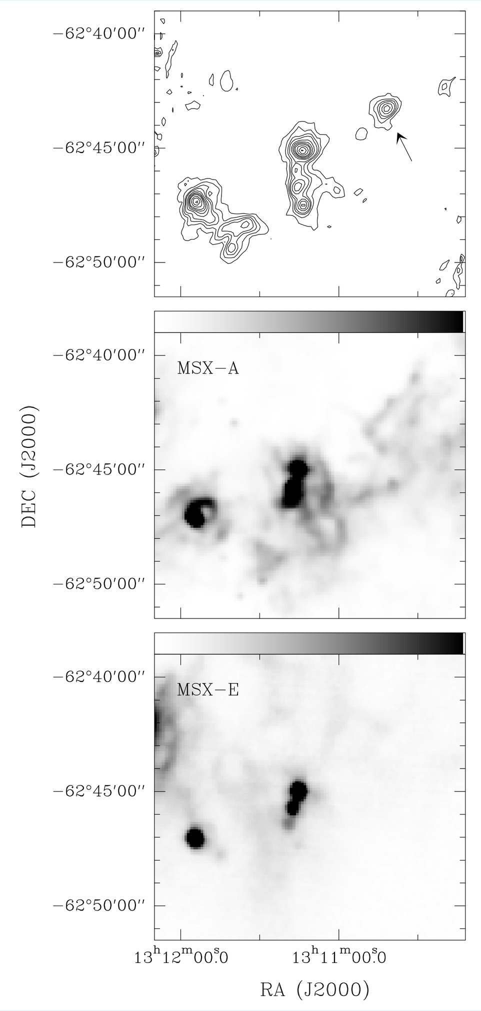

Figure 1: *Top: Contour map of the dust emission at 1.2-mm. The arrow indicates the position of the cold core. Middle: MSX band A image. Bottom: MSX band E image.*

Observations

The observations were made using the Atacama Submillimeter Telescope (ASTE) and the Swedish-ESO Submillimeter telescope (SEST). The observed lines and parameters are given in Table 1.

Line	Telescope	Frequency [GHz]	Beam ["]	Map	Spacing ["]
CS(2-1)	SEST	97980.968	51.3	14	30
CS(3-2)	SEST	146969.049	34.2	14	30
CS(5-4)	SEST	244935.606	20.5	9	30
CO(3-2)	ASTE	345795.990	21.8	25	30
^{13}CO(3-2)	ASTE	330587.960	22.8	25	30
CS(7-6)	ASTE	342882.950	22.0	9	30

Table 1: *Observed parameters*

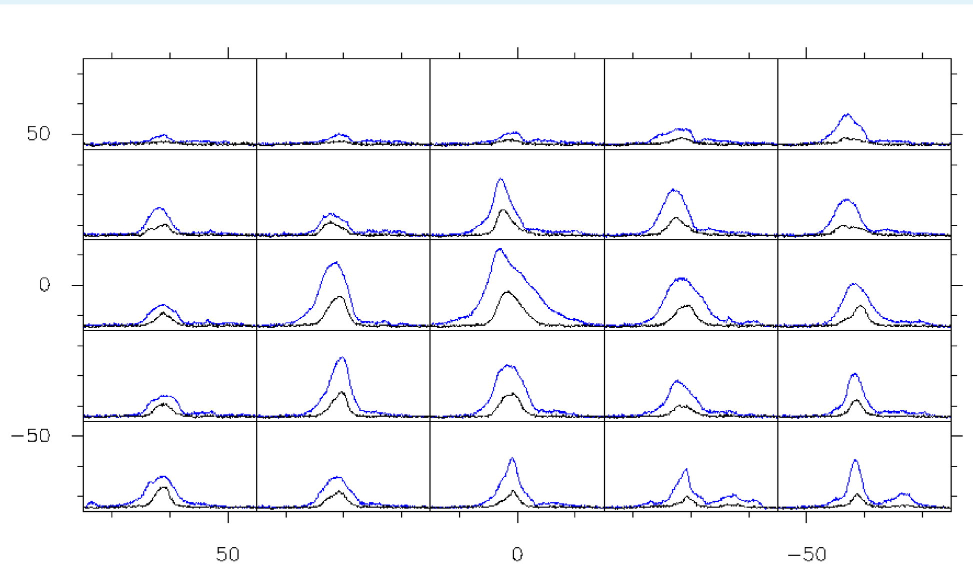

Figure 2: *Spectra of the CO and ^{13}CO emission observed with ASTE.*

Results

- The emission was detected in all the observed molecular lines. Fig. 2 shows the CO(3→2) and ^{13}CO(3→2) spectra observed across the core.
- The emission in all lines arises from nearly circularly symmetric structures. This is illustrated in Fig. 3, which shows maps of the velocity integrated molecular line emission. The size of the core is different in the different transitions, ranging from 0.15 to 0.5 pc (assuming a distance of 3.4 kpc).
- The GLIMPSE images show that the dust core is seen in silhouette in all four IRAC bands and surrounded by a shell of emission (Fig. 4).
- We identified nine IRAC/SPITZER sources within a region of 20" in radius centered at the peak of the dust core.

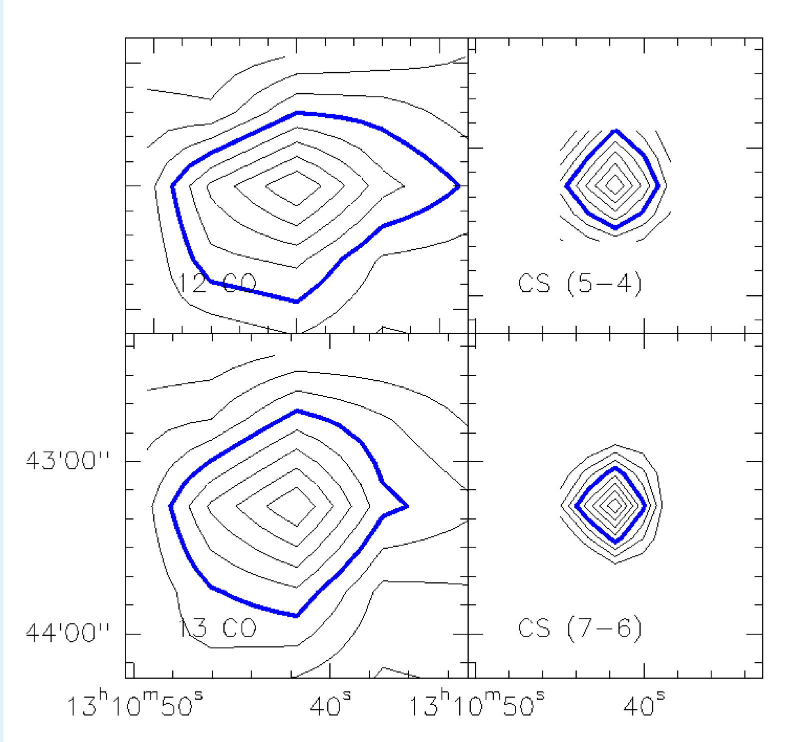

Figure 3: *Contour maps of the emission in CO(3→2), ^{13}CO(3→2), CS(5→4) and CS(7→6) lines.*

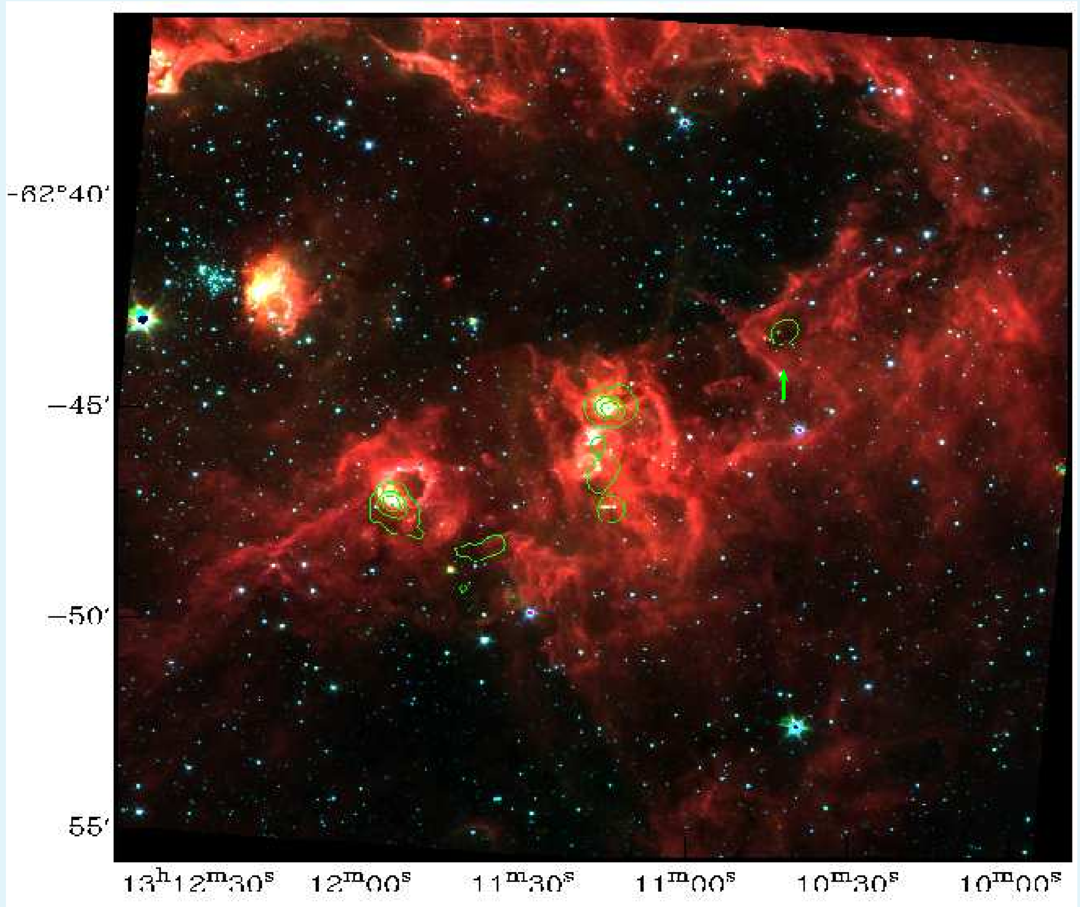

Figure 4: *Spitzer image of the 3.6μ, 4.5μ and 8μ emission towards the G305.136+0.068 region overlayed with the 50% contour level of the 1.2-mm emission. The position of the cold core is indicated by the arrow.*

Discussion

Core physical parameters

From the CO(3→2) and ^{13}CO(3→2) observations we determined, assuming LTE excitacion conditions, a core mass of 1.5×10^3 $M_\odot$. For this estimation we adopted an excitation temperature of 15 K and a [CO/^{13}CO] abundance ratio of 50.

From dust continuum observations at 1.2 mm, Garay et al. (2004) estimated a mass of 1.1×10^3 $M_\odot$, assuming a dust temperature of 16 K.

Another estimation can be obtained assuming that the core is in virial equilibrium. Using the values determined from the CS observations (Δv=6.0 km s^{-1} and R = 0.15 pc) we find a virial mass of 1.4×10^3 $M_\odot$.

The masses and densities derived using the three different methods, summarized in Table 2, are in excellent agreement.

Method	Mass ($M_\odot$)	Density (cm^{-3})
LTE	1.5×10^3	7.8×10^5
Virial	1.4×10^3	7.1×10^5
Dust	1.1×10^3	5.9×10^5

Table 2: *Derived parameters.*

We conclude that the G305.136+0.068 dust core corresponds to a massive and dense core, with parameters similar to those of molecular cores harbouring already formed high-mass stars.

Embedded Sources

We found 9 IRAC/Spitzer sources within a radius of 20" centered at the peak position of the dust core. Five of these sources were detected in the 2MASS survey at near-infrared wavelengths.

For the sources with enough data we fitted their SEDS using a large grid of precomputed models (Robitaille et al. 2007). We find that three IRAC sources are likely to be deeply embedded in the core, two of which are candidate for young high mass protostars still in the process of formation. The SEDs of these sources and model fits are presented in Fig. 5. The solid-line indicates the best fit, which in both cases corresponds to collapse models with large accretion rates of $\sim 1 \times 10^{-3} M_\odot yr^{-1}$.

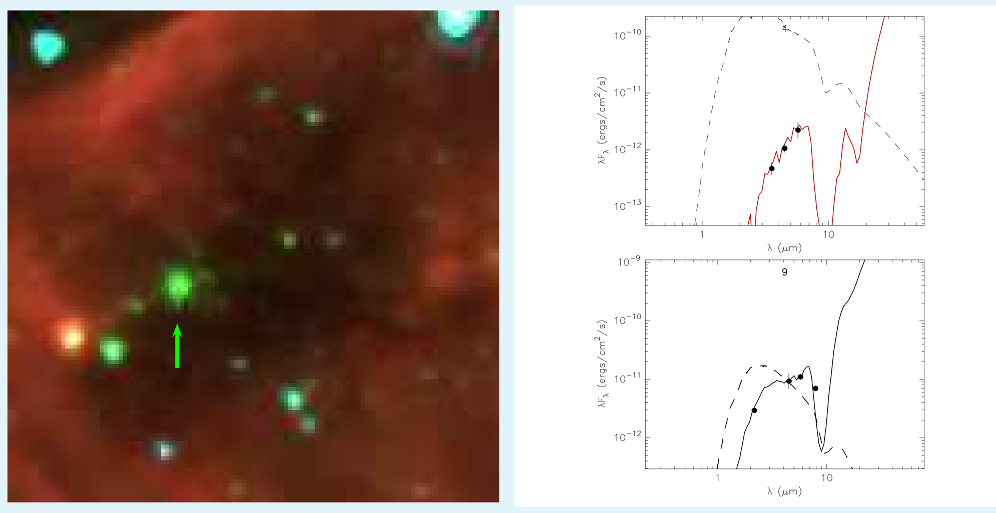

Figure 5:*SEDs of embedded sources. Solid-line: best fit to the SED. Dotted-line: stellar photosphere model implied by the best fit model.*

Modeling line spectra

We are currently in the process of modeling the CS line profiles (in the four observed transitions) with model profiles obtained using a Monte Carlo radiative transfer code developed by Mardones (1996). The best model obtained so far, shown by the dotted line in Fig. 6, is a power law model with the density decreasing with radius as $n = 1.4 \times 10^5 (\frac{r}{0.1pc})^{-1.4}$ and the temperature decreasing inwards as $T = 30(\frac{r}{0.1pc})^{0.7}$.

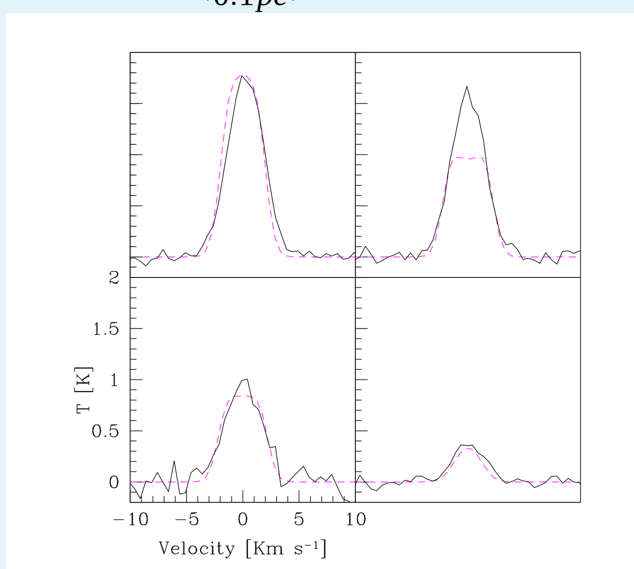

Figure 6: *CS spectra observed at the peak position of the cold core. Dotted-line: modeled spectra.*

Conclusions

- The molecular line observations indicate that G305.136+0.068 is indeed a massive ($M \sim 1.5 \times 10^3 M_\odot$) and very dense ($7.8\times10^5$ cm^{-3}) core. Molecular cores with these characteristics are thought to be the maternities of high-mass stars.
- The IRAC/SPITZER data indicates that the core harbors two high-mass YSOs undergoing accretion with high infall rates ($\sim 1 \times 10^{-3} M_\odot\, yr^{-1}$).
- The new observations support the hypothesis that G305.136+0068 is a massive and dense core in an early stage of evolution, in which the formation of high-mass stars have just started.

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