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MOLECULAR GAS KINEMATICS AND HIGH-MASS STAR FORMATION IN THE SPIRAL ARMS OF THE MILKY WAY

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RESUMEN

Estudiamos la cinemática del gas molecular mediante la línea rotacional ^{12}CO(J=1→0), así como la formación estelar que trazan las regiones HII ultracompactas en el IV cuadrante galáctico ($270^\circ \leq l \leq 360^\circ$). Mostramos que hay una conexión entre (1) la formación de estrellas masivas en los brazos espirales, (2) el gas molecular de alta densidad columnar y (3) los movimientos a gran escala observados en el gas. Estos últimos implican que hay menos momento angular a disipar en los procesos de formación estelar. Mostramos un sistema múltiple en estudio, que está embebido en su nube molecular en Carina.

ABSTRACT

We study the kinematic of the molecular gas using observations of the rotational line ^{12}CO(J=1→0), and also the star formation traced by Ultra-Compact HII regions in the IV galactic quadrant ($270^\circ \leq l \leq 360^\circ$). Our results show that there is a connection between 1) high-mass star formation in the spiral arms of the Milky Way, 2) molecular gas of high column density, and 3) the large-scale rigid-body-like motion of the gas. The large-scale rigid-body-like motions observed in the arms imply that there is less angular momentum to dissipate in the formation processes of stellar systems. We show a multiple stellar system under study, embedded in its parent molecular cloud in the Carina arm region.

Key Words: **BINARIES: CLOSE — GALAXY: KINEMATICS AND DYNAMICS — ISM: MOLECULES**

High-mass star formation is possibly related to the large-scale, rigid-body-like, motion of molecular gas in the spiral arms of the galaxy. This type of motion may increase the frequency of formation of clusters of massive stars. We undertake this topic for large galactic scales using ^{12}CO(J=1→0) (Bronfman et al. 1988) as a tracer of the molecular gas kinematics in the Milky Way disk, as well as the largest data set of high-mass star formation regions there (IRAS-CS sources, Bronfman, Nyman & May 1996). A complete analysis is presented by Luna (2003). Here we discuss those results and show an example of a multiple stellar system still embedded in its parent molecular cloud.

For galactocentric distances associated with the position where the spiral arms are tangent to the line of sight (vertical dot-dashed lines in Fig. 1-B and horizontal lines in Fig. 1-A), the kinematics observed closely resemble those of a solid body, i.e., $V/R = \Omega \approx$ constant and $-A/B \ll 1$. Stability analysis suggests (Luna et al. 2002) that giant molecular clouds are stable and not destroyed by tidal disruption in these arm regions. However, tidal disruption appears to be the agent for giant molecular clouds destruction in the inter-arm regions. This fact could facilitate the accumulation of molecular gas in the arms, increasing the gas surface density locally and promoting the observed star formation, Fig. 1-B.

Using the kinematic parameters that compare gravitation versus shear, Luna (2003) proposed to define as "spiral arm at tangent points" those regions where there are relative maxima in the integrated intensity of molecular gas and where shear disruption of the clouds has less influence than gravitational instabilities. In that case molecular gas can pile up to form giant clouds (like that in Fig. 1-C) that will merge via collisions, and collapse to form stars. The large-scale rigid-body motions observed in three galactic spiral arms imply that there is less angular momentum to dissipate during the formation processes of isolated and multiple stellar systems.

The best candidate to look for multiple systems is the Carina arm, because of its position. If our observed kinematic is extensive to the Carina arm, multiple systems, such as that related with IRAS-CS source l = 286.203, b = 0.170, would have less angular momentum to dissipate during their formation. We show the position for this young stellar system in Fig. 1-A. In Fig. 1-C we show the molecular cloud observed in ^{13}CO (Luna et al., in preparation),

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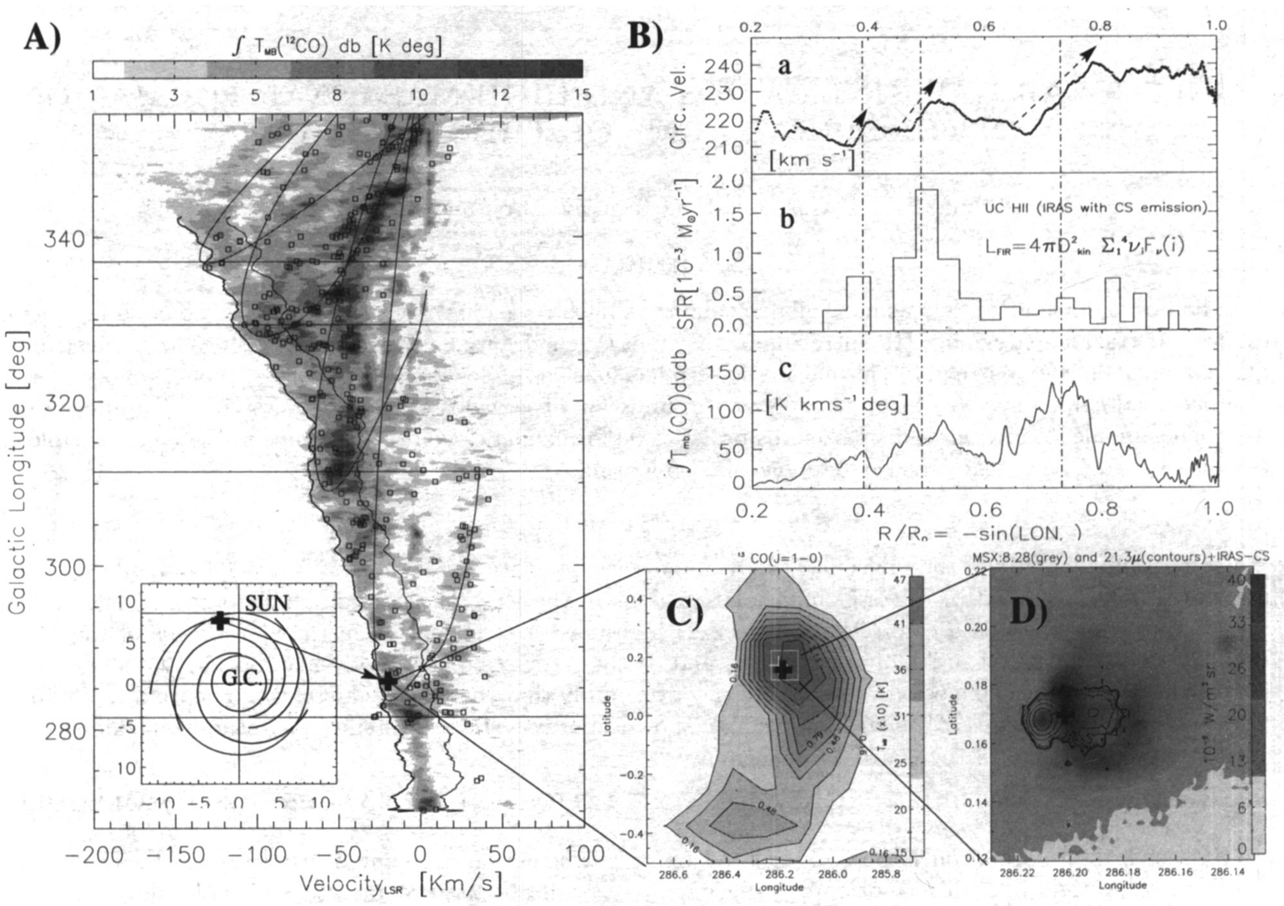

Fig. 1. **A)** longitude-velocity ($l-v$) diagram for the IV galactic quadrant of ^{12}CO(J=1→0) integrated intensity (grey levels). Over-plotted is the IRAS-CS sources in small squares. For reference we plot spiral arms (loops) and the terminal velocities vicinity (from thick line+30kms^{-1} for each longitude). Horizontal lines mark the tangents to spiral arms. Insertion shows logarithmic spiral arms corresponding with those shown in the $l-v$ diagram but in (R,θ) coordinates. **B)** Adapted from Luna et al. 2002, shows the rotation curve in (a) the high-mass star formation rate in (b) and the integrated intensity from ^{12}CO molecular gas in (c). **C)** We show a nearest early multiple system still embedded in its parent giant molecular cloud, we show the molecular cloud in ^{13}CO and the location for the system under study. The multiple system is a IRAS source (l=286.203,b=0.170) detected also in the CS(J=2-1) molecular emission. We compare with MSX maps in **D)**: 8.28 μm (Band A, in grey scale) and 21.3 μm (band E in contours). Band E shows a binary system and band A a possible dust like disk around one of the components.

and in Fig. 1-D the comparison with data from the Midcourse Space Experiment survey (MSX satellite, Mill et al. 1994) at 8.28 μm (Band A, in grey scale) and 21.3 μm (band E in contours) that show at least three components for this system. Recent bolometric observations at 1mm with the Swedish ESO Submillimetre Telescope (Bronfman, private communication 2003) show, in the disk-like emission at 8 μm, at least three more components.

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