Molecular Clouds on the HII region N11 in the Large Magellanic Cloud

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The star formation is extremely important to the galaxy evolution: in this research we studied the star formation region N11 located in the Large Magellanic Cloud (LMC). We calculated physical properties of the molecular clouds in N11 through the CO emission (CO_{1-0} and CO_{2-1} lines transitions) such as radii, masses, luminosities, temperatures, which told us that the molecular clouds have sizes similar to the Giant Molecular Clouds in our galaxy and their temperatures show that they are near a HII region.

We obtained the masses by two different methods CO intensity and Virial analysis that allowed us to estimate a value of the convertion factor X in N11 which was 4.8 times higher than galactic X-factor. This results could be contrasted with other results from SMC and other region in LMC.

INTRODUCTION

The ISM of the Magellanic Clouds presents an environment very differents from that found in the solar neighboord. These galaxies are irregulars, have a smaller gas to dust ratio and also have a low metallicity. These features, including that they are very close to our galaxy, allow a deep study of their ISM.

In particular, the Large Magellanic Cloud shows interesting star formation regions like N11 located is its nortwest part. After 30 Dor, N11 is the largest HII region and the brightest one and contains OB associations and several molecular clouds. In the image we can see the location of the N11 in the LMC.
Through the CO emission we can study the molecular clouds in N11 and calculate physical properties like their radii, masses, luminosities.

Figure 1. Location of the N11 region in the Large Magellanic Cloud

DATA

We used CO(2-1) and CO(1-0) lines transitions observations at the frequencies 230 GHz and 115 GHz respectively. The data were obtained during 2001 January and September with the SEST located at La Silla, Chile. The Half Power Beamwidth was 45'' for CO(1-0) and 23'' for CO(2-1). These observations covered three zones of N11 and were fully mapped simultaneosuly in CO(2-1) and CO(1-0) with a sampling of 24''. The reduction was done using CLASS. In order to discriminate molecular clouds by its kinematics we made integrated CO maps in velocities ranges of 2km/s. To compare the emission in CO(1-0) and CO(2-1) convolved the CO(2-1) data to obtain the same spatial resolution.

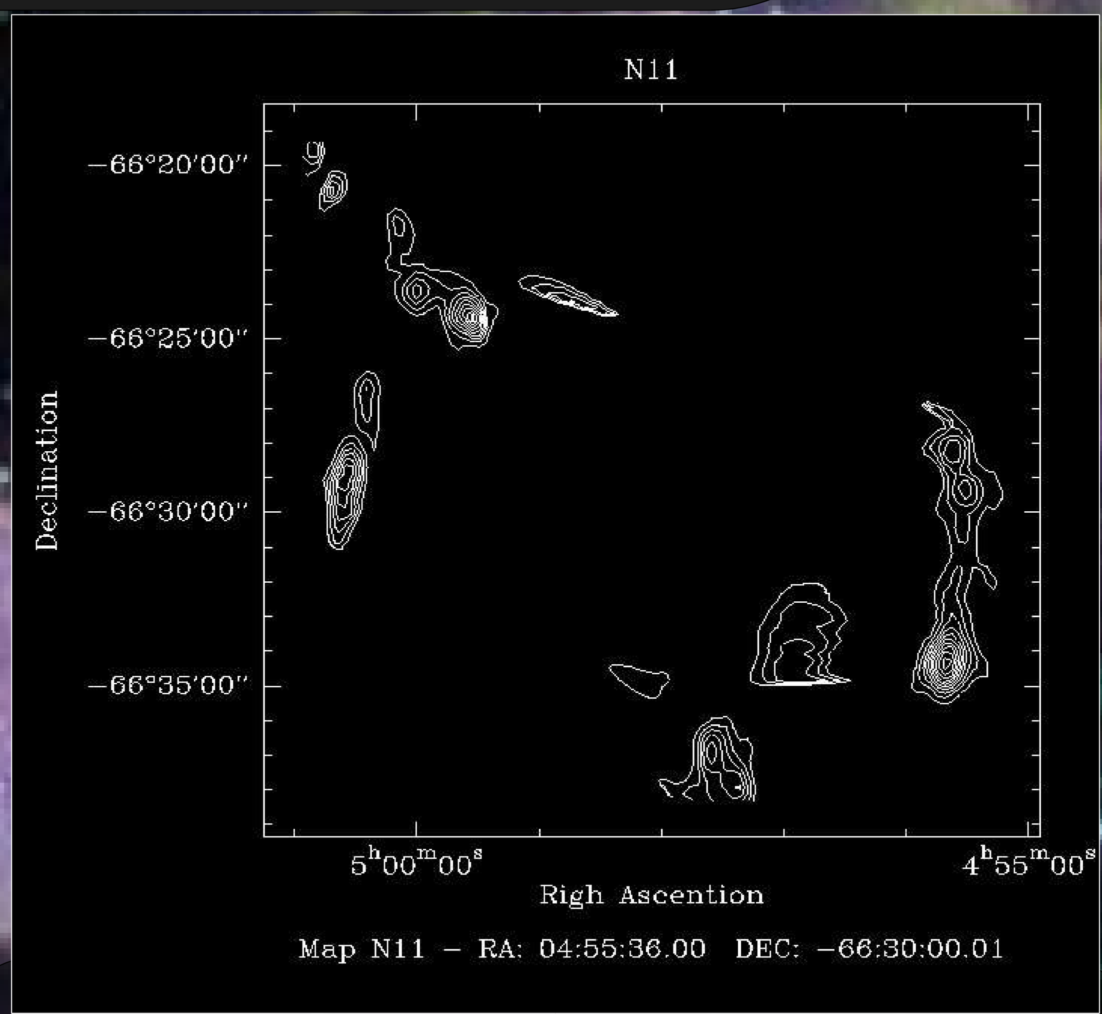

Figure 2. Contours in N11 region, transition CO(2-1)

This is a map of the three covered zones of N11. A ring feature can be seen and in its center there is an OB association. Contours in the map are spaced by 1.3 K km/s, and the first one is 1.7 K km/s (about 5σ).

The contours in figure 4 illustrate the CO(2-1) emission in the transitions (1-0) in red and (2-1) in blue. We can see the difference in the velocities for the components of this zone.

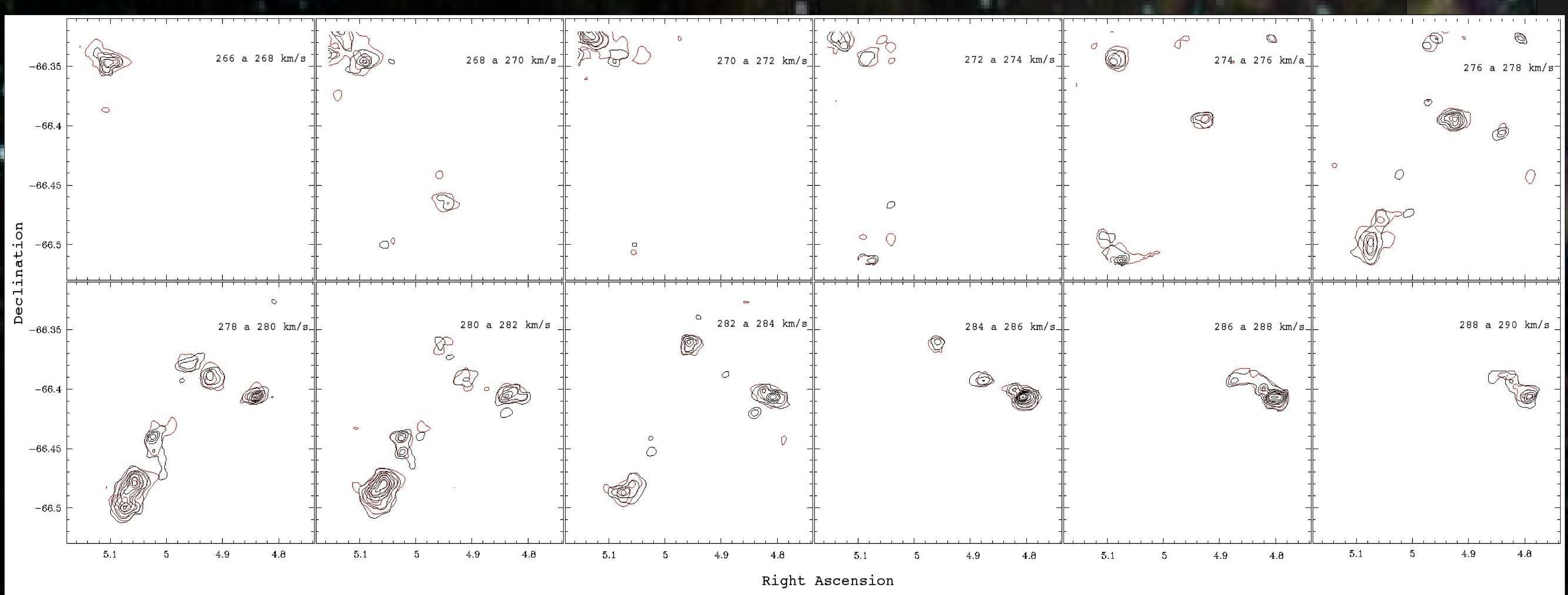

Figure 4. Velocity maps of zone 1 in N11

We also determine CO(2-1)/CO(1-0) ratios for the peak position of the individual molecular clouds. The ratios varied from 0.38 to 1.99 with an average value of 1.1 with standard desviation of 0.6 and a median value of 1.03. These ratios are consistent with gas classified by Sakamoto et al. 1997 as VHGR (Very High Ratio Gas ≥1.0) and HGR (0.7 - 1.0) with temperatures of ~20-30K.

RESULTS

Radii were computed through CO(2-1) transition because those spectra had a better angular resolution. The sizes of the molecular clouds have an average value of 11.4 pc, similar sizes to those of the Giant Molecular Cloud in the Milky Way.

The CO(1-0) luminosities are in a range of 0.28 to 10.02 × 10^3 K km/s pc^2.

The masses were estimated by two methods CO luminosities and virial analysis. L_{CO} was converted into molecular hydrogen column density using the galactic convertion factor X derived by Bloemen et al. 1986 and the value estimated cover a range between 0.8 and 50 × 10^3 M_o. In order to obtain the virial masses we applied a gaussian fit to the integrated emission CO(2-1) lines of the individual clouds to determine its velocity width. Radii were obtained using the area values and approximating the clouds to spheres and compare to radius obtained using CPROPS (Rosolowski et al. 2006). The values computed for the virial masses are in the range 1 – 23 × 10^4 M_o. This result shows that there is an important difference on the values and if we take the average of virial mass and CO mass ratio for all the individualized molecular clouds in N11 we found it is ~4.8± 2.1 (we ignored 2 values of this ratio). The most probable explanation is CO photodissociation due to the UV radiation field that destroy the CO molecule leaving the molecular hydrogen which selfshields. Our results confirms the difference between the X factor in the Galaxy and N11 being in N11 ~4.8 higher than in our galaxy.

Also, we obtained correlations between parameters such as L_{CO} v/s R and M_{vir} v/s L_{CO} (with a determination coefficient r^2 > 0.6). This are similar to those found in Galactic Molecular Clouds (Cohen et al 1988, Solomon et al. 1986). The third graph (Δv v/s R) did not show strong correlation (r^2=0.1).
A previous study in N11 performed by Israel et al. 2003 found a similar slope for M_{vir} v/s L_{CO} of 0.88 (r^2 = 0.6) but the slope for Δv v/s R was 3 times higher than ours.

In the study by Israel et al. 2003 (I03) they used data from SEST (CO_{1-0} and some pointed CO_{2-1}), the difference between both observations is, our observations fully map in CO(2-1) with σ≈0.3 K km/s. The X-factor found by I03 is 1.8± 0.2 higher than the galactic factor while our determination is 4.8 ±2.1.

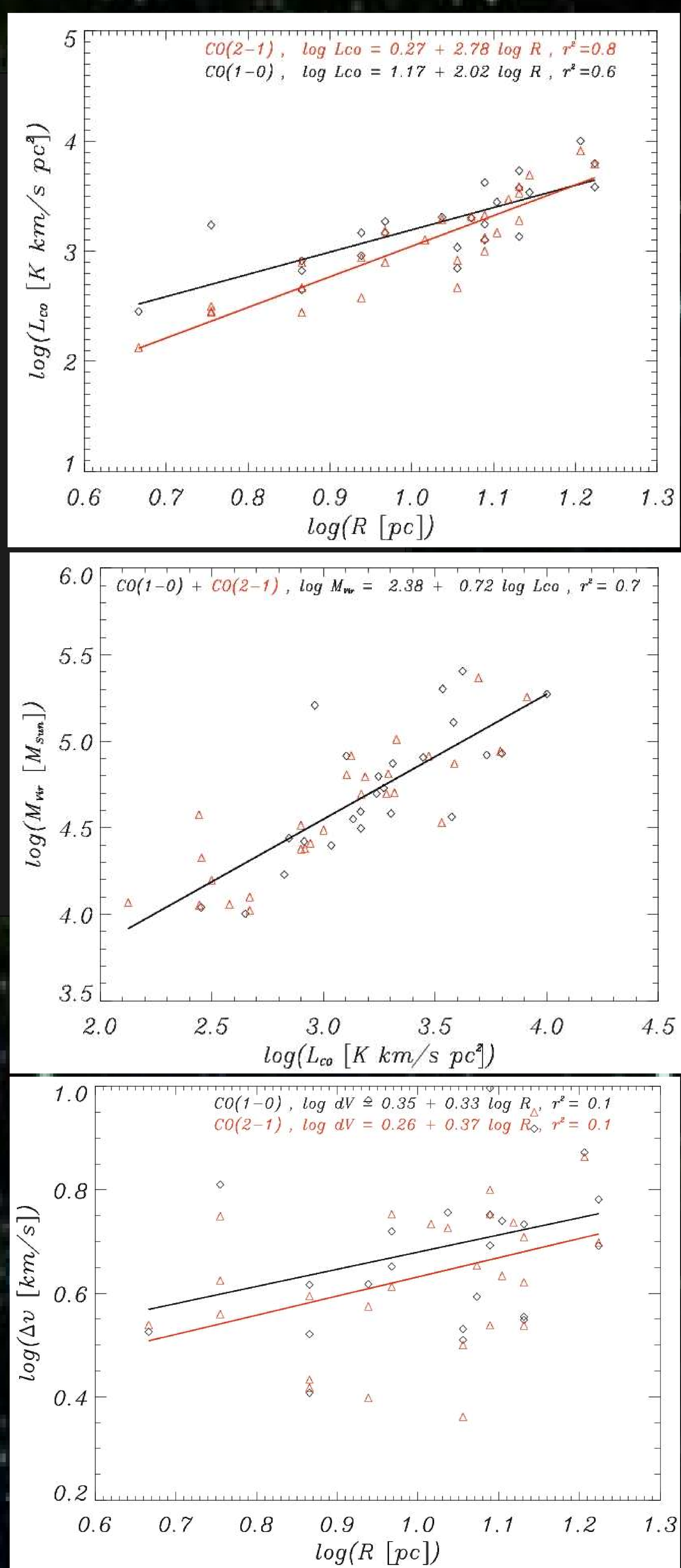

Figure 3. Correlations maps

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