The molecular emission of the irradiated dense core ahead of HH 80N

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ABSTRACT

HH 80N is the optically obscured northern counterpart of the Herbig-Haro 80 and 81 objects. Downstream of HH 80N there is a molecular dense core with a mass of ~20Msun and with star formation signatures. The dense core appears to be contracting with a supersonic infall velocity. This makes HH 80N a distinctive region with respect to the molecular clumps found ahead of other HH objects. In this poster we present the results from the observations, carried out with the BIMA array, of several molecular transitions. The goal is to better understand the physical and chemical properties of the dense core and its relationship with the HH 80N.

INTRODUCTION

HH 80N is the northern optically obscured counterpart of the HH 80/81/80N jet complex, the largest highly collimated jet system known, located at a distance of 1.7 kpc in Sagittarius (Rodríguez et al. 1980; Martí et al. 1993). The strong FUV field generated in the shock associated with HH 80N (Molinari et al. 2001) is expected to alter the surrounding medium. In fact, a dense clump of 20 M was found ahead of HH 80N, firstly detected in ammonia (Girart et al 1994) and afterwards, detected in other species, such as HCO^+ or CS, with unusual abundances with respect to those found in typical molecular clouds (Girart et al 1998). This may be a result of the incoming UV radiation from the HH object that releases some molecules from dust mantles and promotes a process known as photochemistry in some parts of the core (Taylor & Williams 1996; Viti & Williams 1999). However, while the molecular clumps ahead of HH object appear to be small (≤ 0.1 pc; M ≤ 1 solar mass) and starless, the HH 80N clump is that it is larger and more massive (~0.5 pc and ~20 solar masses) and it shows star formation signatures, namely a bipolar CO outflow and a contracting ring like structure with a supersonic infall velocity of 0.6 km s^{-1}. Interestingly this value is higher than values predicted by theoretical models or observed in other collapsing cores (Ohashi et al 1997; 1999; Williams et al. 1999). These peculiarities indicates that the initial physical and chemical conditions of the molecular clump when HH 80N irradiated the clump are quite different from the previous studied irradiate clumps and, hence, the core ahead of HH 80N is a good target to study.

OBSERVATIONS

Several observations were carried out between November 1999 and May 2001 using the BIMA interferometer. We observed several molecular transitions at 3 mm. The typical spectral resolution was set at 0.3 km s^{-1}. In all the observations, the calibration and imaging was performed using the MIRIAD package. The angular resolution achieved was typically ~ 10".

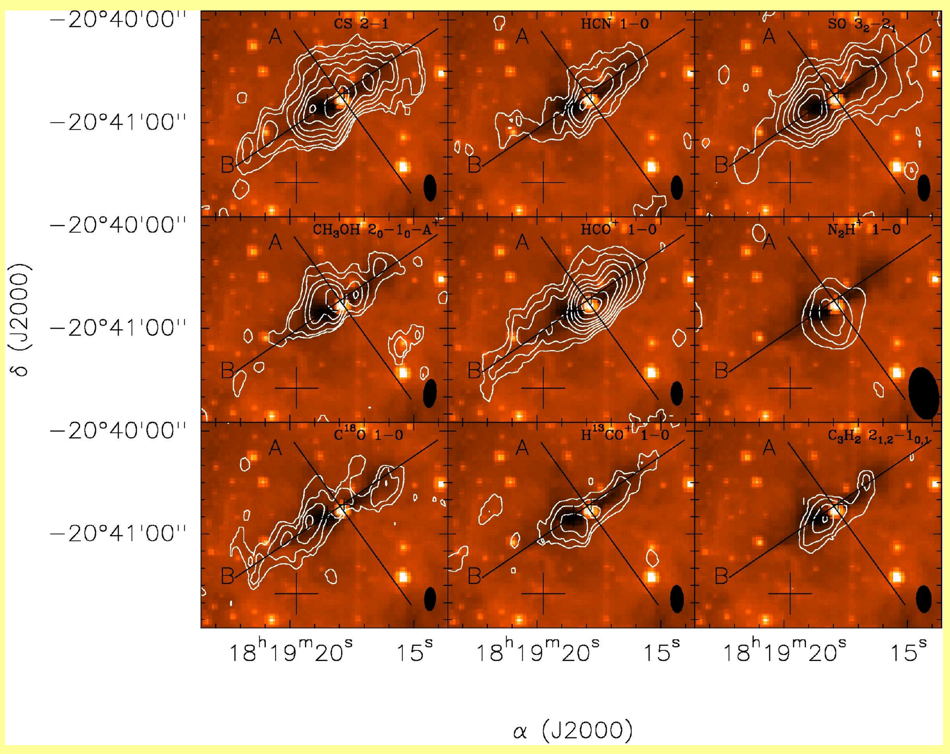

Fig. 1 Zero-order moment integrated over the 9.5-14.09 km s^{-1} velocity range of the species observed with BIMA (white contours) superimposed over the Spitzer 8 μm image (colour image). The Spitzer image shows the HH 80N core in absorption of the background emission (black colour). The beam is shown in the bottom right corner in each panel. The large, medium and small crosses mark the HH 80N object, the NH_3 peak (Girart et al. 1994) and the continuum peak at 1 mm, respectively. The solid lines A (PA. = 32) and B (PA. = 122) represent the minor and major axis of the core, respectively. The central bright source is likely associated with the source powering the molecular outflow detected by Girart et al. 2001.

RESULTS AND ANALYSIS

The integrated emission (Fig 1) shows that all the species share a systematic pattern of an elongated structure with a position angle of ~122 degrees, clearly seen in the Spitzer 8 μm image. However, a detailed inspection of the maps reveals an interesting differentiation between the molecular tracers.

To be able to better study the morphology of different molecular tracers as well as the kinematics of the core we performed a set of position-velocity plot (PV plots) along the major and minor axis of the core that are shown in Fig. 2. Clearly, from the PV plots of CS we deduce that the emission arises from a ring-like structure with inward (or outward) motions and resembles that from the starless core L1544 (Ohashi et al. 1999). The rest of species, although tracing approximately the same region as CS, show important local differences.

In order to analyze the deviations from the CS morphology we used a model of a spatial thin, contracting ring seen edge-on, similar to that of Ohashi et al. (1997) and Girart et al (2001) . Our procedure was to obtain synthetic PV plots for the model and to compare them with the PV plots taken from the data. We adopted the same model parameters found in Girart et al (2001) but leaving the inner (R_{in}) and outer (R_{out}) radii of the ring as free parameters. The best fit for the CS is 15" (2.5 x 10^4 AU) and 35" (6 x 10^4 AU) for R_{in} and R_{out}, respectively. For other species, however, the use of different R_{in} and outer R_{out} does not improve significantly the appearance of the residual PV plots and, hence, we adopted the same values as for CS.

We have divided the emission in several regions in order to better characterize the differences between molecules and between the observations and the model: East Ring, West Ring, CR-Ring, and CB-Ring (that are spatially coincident with the ring morphology), RSE and NB (that appear to be independent from the ring morphology). As these structures are probably a result of a chemical differentiation along the core, we have estimated the relative abundances with respect to CS for the different regions. The results are shown in Fig. 3. where we also report the relative abundances of other environments related with dense molecular material as a comparison.

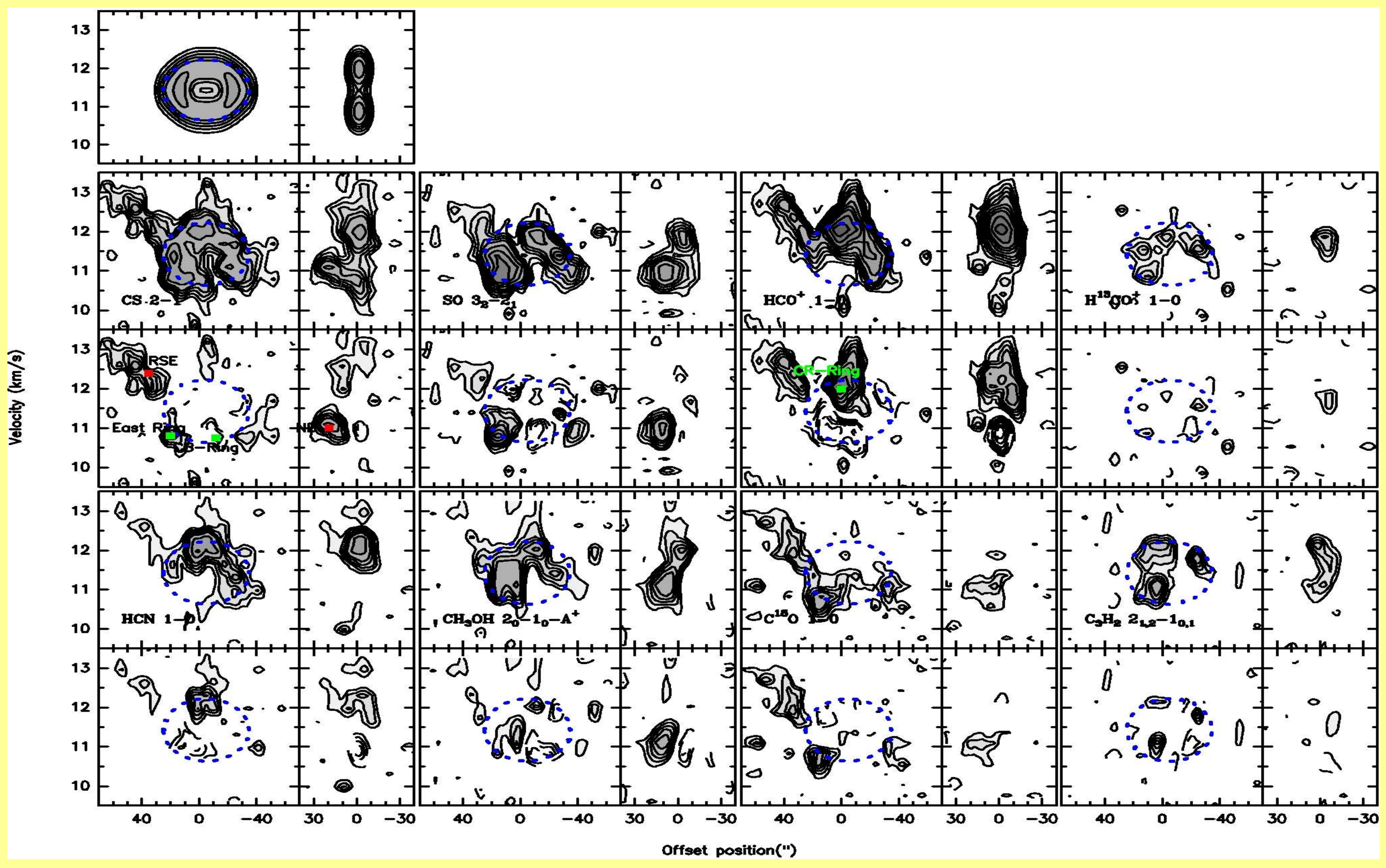

Fig. 2 PV plots for the different species. The two panels at the top show the best fit model (see text) for the major (left) and minor (right) axis of the ring-like structure seen in an edge on view. The rest of the panels show sets of PV plots for the observed lines. For each set, the PV plots of the BIMA data are shown at the top and the residual PV plots resulting from subtracting the data and the model are shown at the bottom. The panels on the left represent the PV plots along the major axis while the panels on the right represent the PV plots along the minor axis of the core. The dashed ellipse show the best fit model for the major axis as a reference. The green and red squares in the CS and HCO^+ residual PV plots mark the features not cancelled out by the ring model belonging to the ring structure and spatially independent from this structure, respectively.

CHEMICAL PROPERTIES AND A SUGGESTED GEOMETRY FOR THE HH 80N SCENARIO

From Fig. 3 we can see that, in general, the observed relative molecular abundances are similar to that found in molecular clumps ahead of HH objects. This suggest that HH 80N is altering the chemistry of the dense core.

A suggested scenario is represented in Fig. 4 where the UV photons impinges mainly on the side of the ring facing HH 80N (East Ring) and on the RSE structure, contrary to NB and CB-Ring (lack of blue-shifted emission) that remains shielded from the UV radiation field.

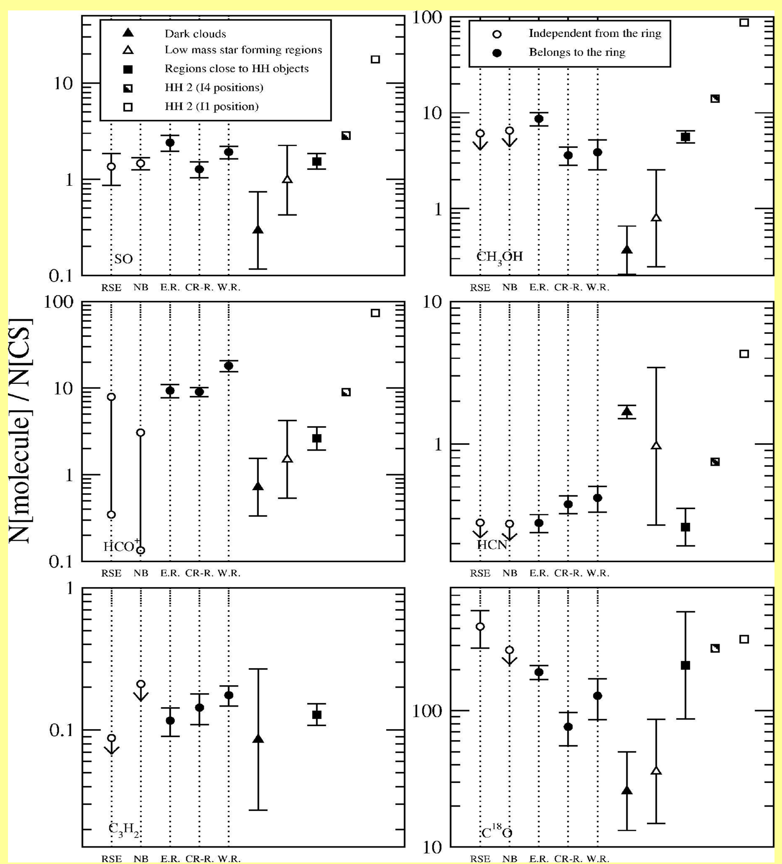

Fig. 3 Relative molecular abundances (with respect to CS) of species observed with BIMA. For each panel, the circles represent the relative abundances for selected positions in the core representative of the structures mentioned in the text, the squares and triangles represents the logarithmic median of the relative abundances found in other environments related with dense gas, and the bars represent the standard deviation. For HCO^+ in RSE and NB positions. we show the resulting limits, correcting for opacity and assuming optically thin conditions.

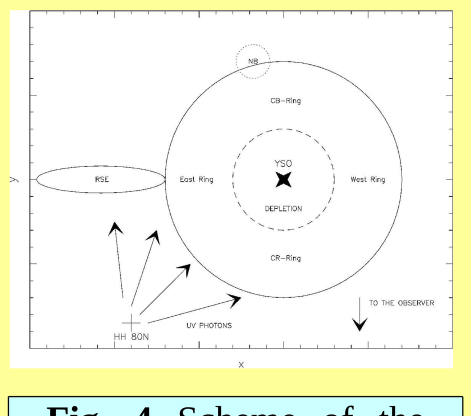

Fig. 4 Scheme of the possible geometry for the scenario involved in the HH 80N region. The core ahead of the HH object is seen face on from the North.

CONCLUSIONS AND FUTURE AIMS

Our results confirms the same trend found by Girart et al. (2001) studying the CS, but for other of species. However, we also find an important chemical differentiation between the tracers, probably due the UV photons incoming from HH 80N. As our results are qualitative, we need a proper modelling to constrain better the chemistry. Understanding and characterizing the chemical structure of the core is crucial to shed light on the star forming conditions within the HH 80N core and provide an explanation for the unusual supersonic infall velocity. For this purpose, continuum observations with good sensitivity combined with multi-transition analysis are required.

STAR FORMATION ACTIVITY IN THE CORE

The presence of a compact source detected at 1.3 mm with BIMA and at 8 μm with Spitzer, in the centre of the core, seems to confirm the existence of an embedded object, probably found in the class 0 stage. In addition, in spite of the high mass of the core (20 Msun),the embedded YSO in the HH 80N core is likely a low-mass object because the estimated low luminosity for this core (20 Lsun, with an important fraction coming from a PDR; Girart et al 1994). As in the Class 0 stage the accretion luminosity is the most important contribution to the luminosity of the YSO, the amount of all the mass of the core may not be falling over a single object and a multiple star formation process is going on (Girart et al. 2001).

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