Modeling the molecular emission of Hot Molecular Cores

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Overview

Hot Molecular Cores (HMCs) are dense molecular clumps at T>100K, found in the proximity of the Ultracompact (UC) HII region. They have attracted considerable interest, since it is believed that high-mass stars are formed within them undergoing an intense accretion phase (Walmsley RMx AC 1 137). In an attempt to investigate quantitatively the feasibility of such scenario, Osorio, Lizano & D'Alessio (1999, ApJ 525 808) modeled the observed dust emission adopting an infalling envelope onto a central O-B star. It was found that massive envelopes with high mass accretion rates and with a density distribution resulting from the the collapse of a singular logatropic sphere (Lizano & Shu 1989, McLaughlin & Pudritz 1997 ApJ 476 750) are able to reproduce the dust emission of HMCs. In order to futher test this idea, here we derive the ammonia emission resulting from the physical parameters obtained from the SED fitting, and we compare the model results with the highest angular resolution molecular observations of HMCs published up to date, such as those carried out toward the HMC in G31.41+0.31 (Cesaroni et al. 1998, see Fig. 1 and 2).

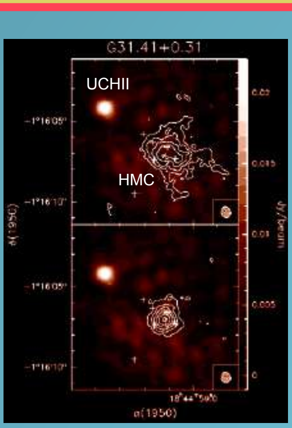


Fig. 1 Contour maps of NH_3(4,4) emission averaged over the main line (top panel) and over all satellite lines (bottom, Cesaroni et al. 1998 A&A 331, 709). The gray scale represent free-free 1.3 cm continuum emssion.

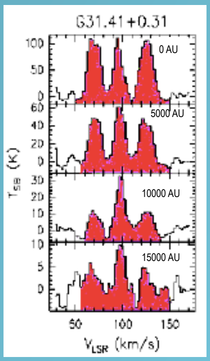
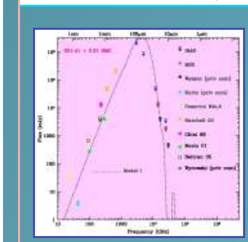


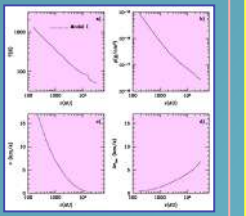
Fig. 2 Spectra of G31.41+0.31 HMC obtained by averaing the NH3(4,4) emission over circular annuli of radius 5000 AU around the core centre.

DUST EMISSION

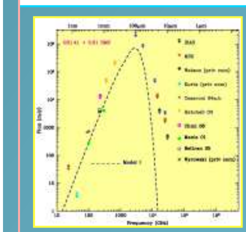
In order to account for the strong millimeter emission of G31 HMC, either a high stellar luminosity or a high density envelope are required.

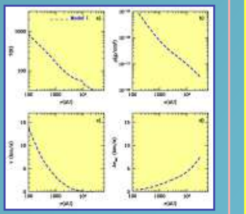
Model I: Very high stellar luminosity + High density envelope
Parameters: M_*=40 Mo, L_*=2 x 10^5 Lo, M_{acc}=2.7 x 10^{-3} Mo/yr.
This model is not able to reproduce the SED.



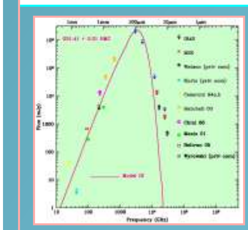


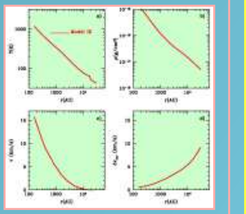
Model II: High stellar luminosity + Very high density envelope
Parameters: M_*=12 Mo, L_*=1 x 10^4 Lo, M_{acc}=1.6 x 10^{-3} Mo/yr.
This model is able to reproduce the SED, but not the molecular emssion.





Model III: Very high stellar luminosity + Very high density envelope. Parameters: M_*=25 Mo, L_*=8 x 10^4 Lo, M_{acc}=2.4 x 10^{-3} Mo/yr. This model is able to reproduce the SED, and the molecular emission taking into account a variable X_{NH3}





MOLECULAR EMISSION

We calculated the molecular emission using the temperature, density, infall velocity and turbulent velocity fields derived from the dust emission. The only free parameter of the molecular modeling is the ammonia abundance relative to hydrogen. It has been explored a constant abundance ranging to 10^{-8} to 10^{-5}. Since the constant abundance cases are unable to explain the observed spectra (see Figs. 4, 5) we used a variable abundance resulting of the sublimation of ammonia molecules trapped in water mantles (see Figs. 3, 7).

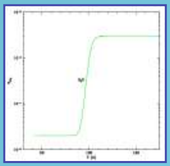
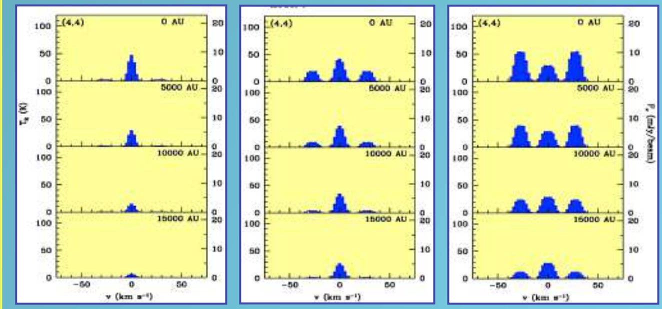


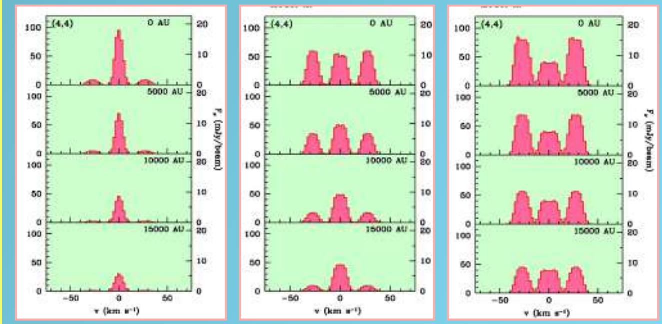
Fig. 3
Ammonia abundance in the gas phase as a function of the temperature in the envelope. Ammonia molecules are assumed to be trapped in water ice mantles and released whe the water ice is sublimated T~100K) (see Sandford & Allamandolla 1993, ApJ. 417,815).

Constant Ammonia Abundance



Model II X_{NH3}=5 x 10^{-8}
Model II X_{NH3}=5 x 10^{-7}
Model II X_{NH3}=5 x 10^{-6}

Fig. 4. Model II adopting a constant abundance. Compare with Fig. 2 and note that these cases are unable to reproduce simultaneously the main and satellite lines.



Model III X_{NH3}=5 x 10^{-8}
Model III X_{NH3}=5 x 10^{-7}
Model III X_{NH3}=5 x 10^{-6}

Fig. 5. Model III adopting a constant abundance. Compare with Fig. 2 and note that these cases are unable to reproduce simultaneously the main and satellite lines.

Variable Ammonia Abundance

X_{NH3}=2 x 10^{-8} (outer envelope)
X_{NH3}=3 x 10^{-6} (inner envelope)

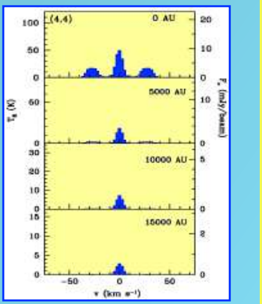


Fig. 6. Compare with Fig. 2. Note that Model II even with a variable abundance is unable to explain the observed spectra.

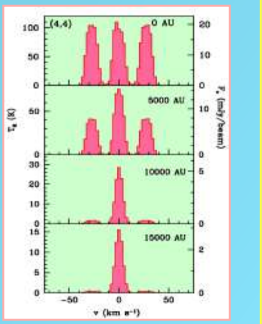


Fig. 7. Compare with Fig. 2. Note that Model III explains reasonably well the main characteristics of the observed spectra.