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Characterizing the densest parts of dark clouds through N_2H^+ observations

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Abstract. N_2H^+ is a molecule particularly suitable for the study of the densest parts of molecular clouds. It is thought to be a late depleter because of the low binding energy of nitrogen with ice mantles and thus, may lead to estimates of geometrical and dynamical characteristics of the densest parts of protostellar cores, up to densities of a few 10^6 cm^{-3}. The existence of a hyperfine splitting of the energy levels of rotation create complex spectra with a great number of transitions associated to each rotationnal lines. The shape of this spectra is then strongly dependant of the density and abundance profiles. In collapsing or expanding regions, the 2-1 and 3-2 lines lead to great constraints on the velocity structure due to these transitions with different opacities.

We present observations of the 1-0, 2-1 and 3-2 lines of N_2H^+ obtained at the IRAM 30-m telescope for a set of dark clouds which are in different stages of gravitationnal collapse. We investigate the properties of these clouds by performing non-local radiative transfer calculations and using new collisional rates between the hyperfine energy levels. For each cloud, the density is described according to the model of inside/out gravitational collapse of Shu, F.H. (1977), i.e $n_{H_2} \propto n_0 r^{-\alpha}$. For the quiescent part of the cloud, i.e $r > r_0$, the power law index is set to 2 while it is allowed to vary in the range $1 < \alpha < 2$ in the inner part. For each source we determine the most reliable values for α, r_0 and for the abundance of the molecule. In figure 1 is shown the modelised spectrum for the cloud L63.
We find that for this set of sources, the best agreement between models and observations is obtained when alpha ~ 1.2 . Such a central flattening in the density profiles has been previously reported by Caselli, P. et al. (2002) in order to reproduce maps of N_2H^+(1-0) integrated intensity. Also, in most sources, we had to introduce a central decrease in the abundance of N_2H^+ , for densities higher than a few 10^6 cm^{-3}.
Our models show that the 2-1 transition is particularly suitable to constrain the radial velocity fields of the clouds: opacity effects associated with an infall speeds around $v_{infall} \sim 0.1$ km.s$^-1$ give rise to specific shapes for this transition.

Keywords. ISM: abundances, ISM: molecules

References

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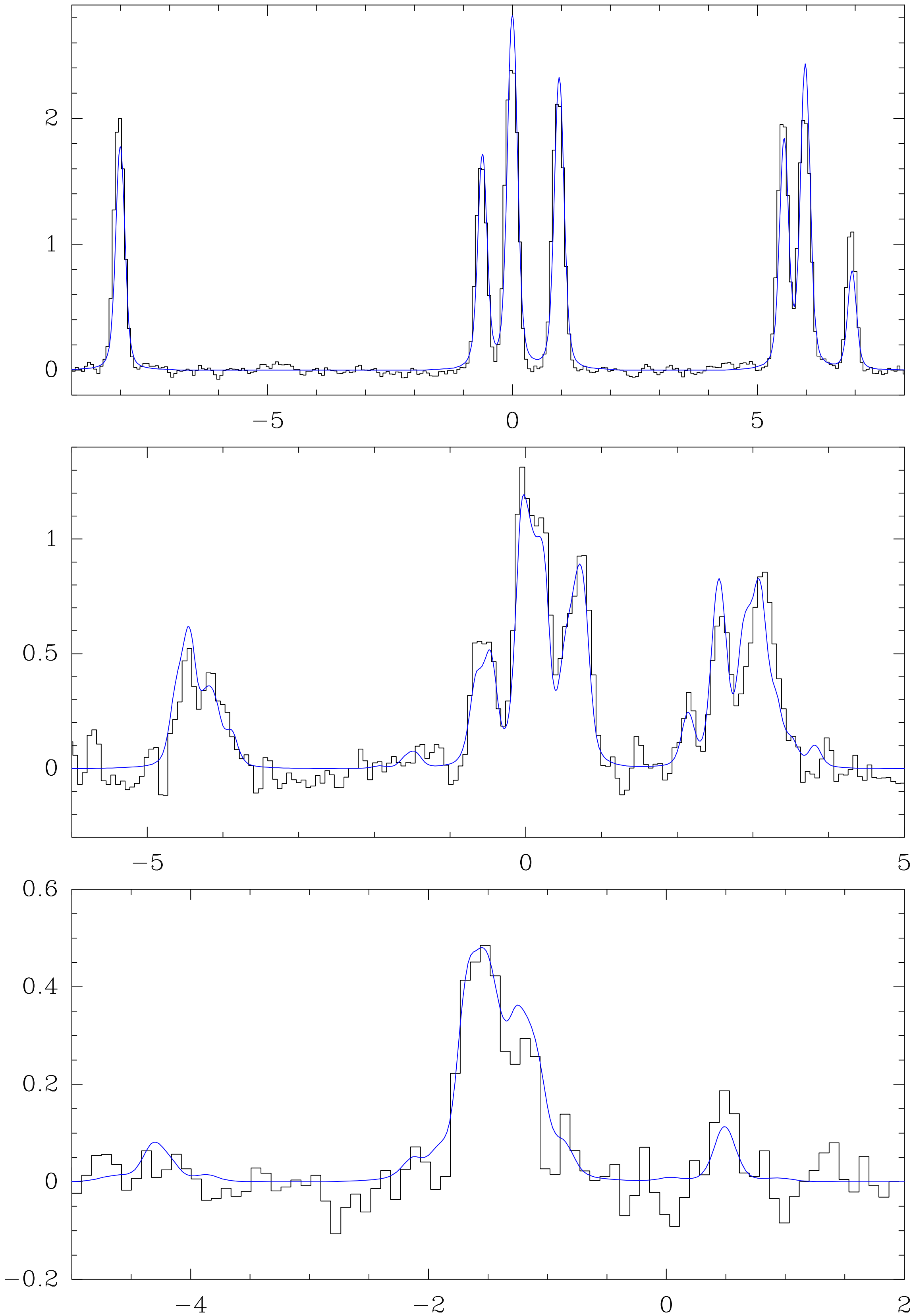

Figure 1. Observed lines of the transitions 1-0 (top), 2-1, 3-2 (bottom) of N_2H^+ in L63 compared to the model adopted for this source.