$^{15}NH_3$ MILLIMASERS TOWARD NGC 7538–IRS 1

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1. Observations and Results

Ammonia towards the UCHII–region NGC 7538–IRS 1 shows an extremely hot component observed in absorption in several transitions and a so far unexplained (9,6) maser (see Fig. 1). This source is the only known source in the Galaxy where the 141 GHz line (1450 K above ground) of vibrationally excited Ammonia is seen in absorption (Schilke et al. 1990). An additional unique feature is the $^{15}NH_3(3,3)$ maser observed by Mauersberger et al. (1986) in Effelsberg and by Johnston et al. (1989) with the VLA. There are theoretical models to explain such a maser (see e.g. Flower, Offer and Schilke 1990) in low density regions where ortho-H_2 is underabundant. In this study, our aim was to investigate $^{15}NH_3$ in more detail. We succeeded in observing the (1,1) and (2,2) lines of $^{15}NH_3$ in absorption and, surprisingly, the (4,3) and (4,4) lines in emission (see Fig. 1).

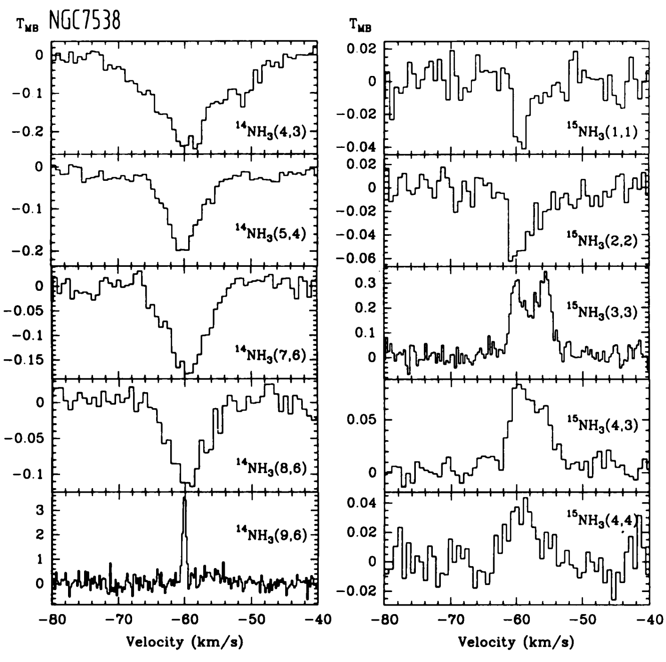

Fig. 1. Spectra of $^{14}NH_3$ (left) and $^{15}NH_3$ (right)

E. Falgarone et al. (eds.), Fragmentation of Molecular Clouds and Star Formation, 489–490.

We conclude that the (4,3) and (4,4) lines are weak masers amplifying the continuum background of NGC 7538-IRS 1. The $^{14}NH_3$ lines show no pecularities. In a Boltzmann–plot for the $^{14}NH_3$ absorption lines, one finds a rotation temperature of 150 K. The total $^{14}NH_3$ column density is $5 \cdot 10^{18}$ cm^{-2}. The linear shape of the plot suggests thermalization and therefore high H_2–densities ($> 10^6$ cm^{-3}).

2. Theoretical Model

The current model of Flower, Offer and Schilke (1990) fails to explain the (4,3) and (4,4) emission. Hence, we decided to look at other possibilities. The detection of the vibrationally excited line (Schilke et al. 1990) gave us a hint that the first vibrationally excited state may be involved in the pumping process. And indeed, a comparison of the transition probabilities shows that transitions via the vibrationally excited state lead to inversion. The molecules are pumped to the $v_2 = 1$ state by absorption of 10μm IR photons emitted by hot, local dust. A critical dust temperature for this process can be derived based on the approach of Carroll and Goldsmith (1981). One compares the probabilities for rotational transitions with these for vibrational transitions. It turns out that the critical dust temperature is in the order of 130 K.

Detailed calculations were performed using a 260 level LVG statistical equilibrium program. The results agree qualitatively with the simple estimates. Trapping in the highly optically thick transitions of $^{14}NH_3$ seems to quench the inversion of this species, as seen in calculations with a 300 times higher NH_3 abundance. The absence of the $^{14}NH_3$ counterpart of the $^{15}NH_3$ masers can therefore be explained in the frame of the model.

References

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