FIRST DETECTION OF GROUND STATE ROTATIONAL LINES OF DOUBLY DEUTERATED AMMONIA

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We report the first detection of the $N_{K_A K_C} = 1_{11} \rightarrow 0_{00}$ and $1_{10} \rightarrow 0_{00}$ ground state rotational lines of o-ND_2H at 335.5 and 388.7 GHz, obtained in the Lynds 1689N and Barnard 1 molecular clouds using the Caltech Submillimeter Observatory (CSO). The hyperfine splitting is detected in both lines allowing direct determination of the line opacity and the excitation temperature. The $1_{11} \rightarrow 0_{00}$ line of p-ND_2H at 335.4 GHz is also detected in both sources and the derived ortho-to-para ratio is consistent with the expected LTE value of 2:1. The two ground state o-ND_2H transitions have different spontaneous emission rate coefficients and therefore critical densities. With the help of modeling tools, they can thus provide good constraints on the excitation conditions and gas kinematics in dense, cold pre-stellar and protostellar cores. These places are sites of strong molecular depletion and heavy deuteration. Non-accreting molecules, H_3^+ and its isotopologues, are difficult to study, but in several cases it appears that ammonia and its isotopologues are not completely frozen out. On good sites, such as Mauna Kea or Chajnantor, the submillimeter ND_2H lines are easier to detect than the 3 mm lines previously used to study the distribution and abundance of this molecule in the interstellar medium. Interferometric observations of these submillimeter ND_2H lines with the Submillimeter Array (SMA), and subsequently the Atacama Large Millimeter Array (ALMA), will provide new opportunities to image the inner structure of cold, dense cores, where most molecules are depleted onto dust grains.