Constraining the primary nitrogen reservoir and formation history of ammonia ices in star-forming regions through VLA observations of ammonia deuteration

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Investigating molecular isotopic ratios such as D/H ratios around low-mass protostars is essential to understand the chemical origin of our Solar system. In the hot (> 100 K) region around protostars, major volatiles such as H_2O, CH_3OH, and NH_3 have sublimated from the dust grain surface to the gas phase, allowing for constraining its abundance or isotopic ratio with radio molecular line observations. We observed multiple NH_3 and NH_2D transitions toward the protobinary system NGC1333 IRAS4A (4A1 and 4A2) with Karl G. Jansky Very Large Array (VLA) at a high angular resolution (~1 arcsec or ~300 au). We detected NH_3 high excitation lines toward both of the binary, indicating the hot NH_3 gas in the vicinity of the protostars. Two NH_2D high excitation lines are also tentatively detected. Employing the local thermodynamical equilibrium (LTE) analysis, we found remarkably high NH_2D/NH_3 ratios of ~1.0 and ~0.5 with excitation temperatures of ~100 K and ~160K for 4A1 and 4A2, respectively. Such high NH_2D/NH_3 ratios may indicate the relatively late formation of NH_3 ices in the parent molecular cloud, and that the primary nitrogen reservoir in the molecular cloud can be the atomic nitrogen rather than icy nitrogen-bearing species such as N_2 and NH_3. Compared with recent ALMA observations of deuterated water, it is suggested that the formation stages of water ices and ammonia ices are significantly different in the interstellar medium.

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