Detection of Chemically Young Dark Cloud Cores in the Aquila Rift

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In the last decade, we have carried out a survey of radio spectral lines of NH_3 and carbon-chain molecules such as CCS and HC_3N with the Nobeyama 45 m radio telescope. Because carbon-chain molecules and NH_3 are expected to be abundant in the early and late stages of chemical evolution, respectively, due to different production timescales, the abundance ratio of NH_3/CCS can be used as one of the good indicators of chemical evolutionary phase of dark cloud cores.

Recently, we extensively surveyed the NH_3 and CCS lines in the Aquila Rift region, for which observational studies with molecular lines were still limited. As a result, two dense cores, CB130-3 and L673-SMM4, were detected which show remarkably intense spectra of carbon-chain molecules compared with the weak NH_3 lines [1]. According to their high NH_3/CCS ratios, they could be chemically and dynamically less evolved dense cores. Such chemically less-evolved dense cores have been found only in the Taurus Molecular Cloud and the Aquila Rift region. This implies a similarity in the physical properties and/or chemical evolutionary phases of these two molecular clouds.

We have also carried out detailed mapping observations of the CCS and NH_3 lines with the Nobeyama 45 m telescope and Effelsberg 100 m telescope of the Max Planck Institute (Figure 1), as well as a survey of other molecular lines such as DNC, $HN^{13}C$, $H^{13}CO^+$, and N_2H^+. Using these data, we compared the chemical abundances of CB130-3 and L673-SMM4 with previously known carbon-chain-rich cores in the Taurus region [1]. According to the NH_3/CCS ratios as well as the DNC/$HN^{13}C$ ratio, which is another good probe of chemical evolutionary phase of dense cores, CB130-3 and L673-SMM4 are found to be analogous to the previously known chemically young cores while their chemical evolutionary phases would be slightly older than those in the Taurus region. These two sources could be good targets to study initial conditions of protostar formation with future high-sensitivity/high-resolution studies with ALMA.

Reference

[1] Hirota, T., Sakai, T., Sakai, N., Yamamoto, S.: 2011, *ApJ*, **736**, 4.

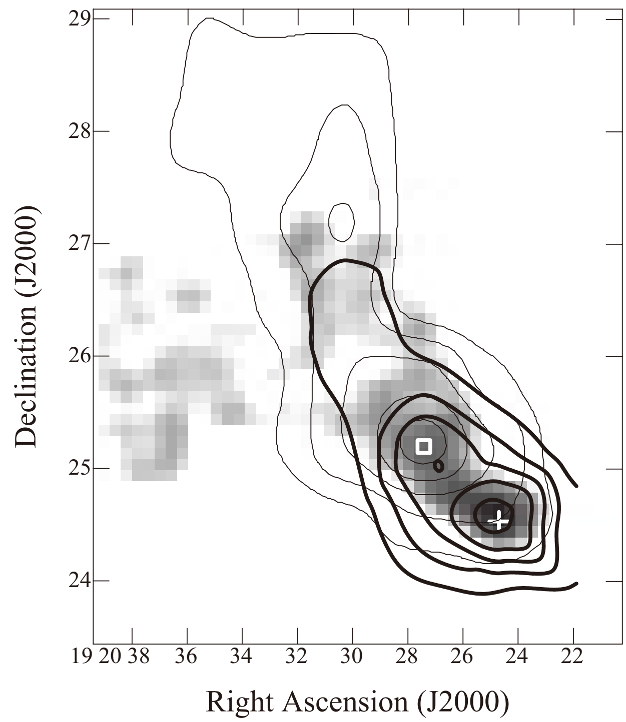

Figure 1: Distributions of CCS (thin contours) and NH_3 (bold contours) superposed on the dust continuum (gray scale) in L673-SMM4. The position offset between the NH_3 (cross) and CCS (square) peaks suggests a chemical differentiation in the core.

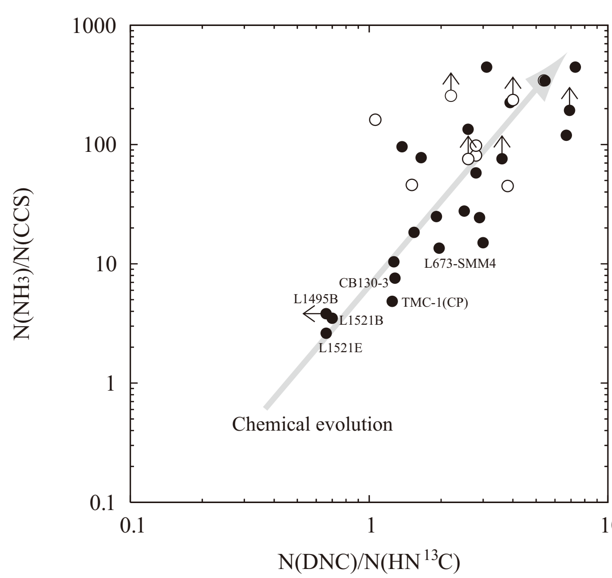

Figure 2: Relationship between NH_3/CCS and DNC/$HN^{13}C$ ratios. Filled and open symbols represent the starless and star-forming cores, respectively. Dense cores evolve from bottom-left to top-right direction (gray arrow).