Radio Observations of Cold Clouds

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A cold dark cloud, Taurus Molecular Cloud-1 (TMC-1) has been observed with the Nobeyama 45-m radio telescope in the frequency region of 9-50 GHz, and the result is reported recently (1). During the survey observation, HCCNC, HNCCC (2), and HC_3NH^+ have been observed. The abundance ratios of these metastable isomers of HC_3N and ^{13}C isotopomers (3) of HC_3N suggest strongly that the HC_3N is produced by neutral-neutral reactions, such as HCCH + CN. The ^{13}C species in CN of HC_3N is found to have higher abundance than other ^{13}C. It is important to determine the isotopic abundance of the CN radical to understand the formation mechanism. However, the isotopic abundance of CN is not reported so far in cold clouds. One reason may be due to a fact that observed line intensities of hyperfine components of CN are apart from usual calculated intensities. The abnormal intensity ratios will be explained by considering collisional rates of hyperfine components with H_2. Recently, we started to calculate collisional cross sections between energy levels with hyperfine splitting to derive the observed intensity ratios. The result will be discussed with observed data.

Observations of cold molecules in external galaxies NGC 253 and M 82 will be presented. Both galaxies are located at distances of about 3 Mpc and are known to contain a starburst. We report radio observations of cyclic-C_3H_2 and H_2CS to investigate chemical processes in external galaxies.

(1) Kaifu et al. Publ. Astron. Soc. Japan **56**, 69 (2004).
(2) Kawaguchi et al. Astrophys. J. **396**, L49 (1992).
(3) Takano et al. Astron. Astrophys. **329**, 1156 (1998).