Nobeyama 45 m telescope legacy project: Line survey (II)

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Line surveys are of fundamental importance in astronomy not only for complete understanding of chemical compositions in representative sources, but also for finding out new observing tools probing interstellar medium and star formation. We started the line surveys toward a few new types of sources with the Nobeyama 45 m telescope in December 2007. The target sources include the low-mass star forming region L1527, the shocked region of L1157, infrared dark clouds G28.34+0.06, and external galaxies Arp 220, NGC 1068 and NGC 253. Mainly with the new 3 mm receivers installed on the 45 m telescope [1], the frequency range of ~84-115 GHz will be surveyed with much higher sensitivity than the previous observations. The total observing time is expected to be about 1000 hours for four years. The results from the survey will be used for detailed studies on chemistry in each source, and will also provide us with useful templates for planning the observing strategy with ALMA. The third year of the line surveys was finished. We report the preliminary results.

L1527 is a very interesting object, because the abundances of carbon-chain molecules are high, though this source is a low-mass star-forming region [2]. We detected many lines including high excitation lines of HC_5N (e.g. J=41-40, upper state energy of 110 K), isotopic species (D, ^{13}C) of some carbon-chain molecules, HCO, C_3O, cyclic-C_3H, etc. These data will be quite useful to understand chemistry in this warm environment.

In L1157, where interactions between an outflow and ambient clouds are prominent [3, 4], we detected many lines including C_2H, $C^{34}S$, CCS, HCNO, CH_3CN, CH_3CHO, $HCOOCH_3$, and NH_2CHO. To study shock chemistry and gas-grain interaction, these results are rather important information. After our observations, we noticed that $HCOOCH_3$ is independently detected with the IRAM 30 m telescope [5].

In G28.34+0.06 three interesting positions called mm1, mm4, and mm9 are selected. Toward mm1 and mm4 line wings were found in HCO^+, HCN, SiO, CS, and CH_3OH. These wings indicate outflow activities. In addition, CH_3CHO is detected only in mm1 and mm4. This molecule is one of the probable grain related species. Therefore CH_3CHO may be evaporated from grain. Based on these results, mm1 and mm4 are thought to be high-mass protostellar objects. Additional data supporting this view were obtained from DNC, DCO^+, and N_2D^+.

About galaxies we are mainly observing NGC 1068, which is a nearby galaxy with Active Galactic Nucleus (AGN). Our motivation is to study the effect of AGN on molecular abundances (cf. [6]). In addition a prototypical starburst galaxy NGC 253 is observed for comparison. We detected C_2H (N=1-0), $H^{13}CN$ (J=1-0), and cyclic-C_3H_2 for the first time in NGC 1068. The details will be presented in this workshop by Nakajima et al.

References [1] Nakajima et al. 2008, PASJ 60, 435. [2] Sakai et al. 2008, ApJ 672, 371. [3] Umemoto et al. 1992, ApJ 392, L83. [4] Mikami et al. 1992, ApJ 392, L87. [5] Arce et al. 2008, ApJ 681, L21. [6] Kohno et al. 2008, Ap&SS 313, 279.