Nobeyama 45 m telescope legacy project: Line survey

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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 type of sources with the Nobeyama 45 m telescope. The target sources include the low-mass star forming region L1527, the shocked region of L1157, infrared dark clouds G28, 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 from 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 first 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, and HCO.

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

In G28 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.

About galaxies we observed only Arp 220 in the first year. In Arp 220 wide absorption lines of ammonia have been detected [6]. We expected such absorption lines for other molecules, which have low excitation lines at relatively low frequency region like ammonia. We tried to find spectral lines of HNCO (21.98 GHz) and SO (30.00 GHz), but they were not detected at the rms antenna noise temperature of 1.0 and 1.5 mK, respectively.

Many new lines were detected in L1527, L1157, and G28. We hope that these results will become invaluable heritages of molecular line data.

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] Takano et al. 2005, PASJ 57, L29.