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Observations of SiO J=2–1 and J=3–2 masers towards evolved stars with the TRAO 14 m telescope

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Abstract. We present the results of survey and time-monitoring observations of SiO J=2–1 and J=3–2 masers towards evolved stars with the 14 m radio telescope at Taeduk Radio Astronomy Observatory (TRAO) from 1995 February to 2001 February. The first detection of SiO v=3, J=2–1 maser emission toward S-type Mira variable χ Cyg is also presented.

Keywords. circumstellar matter, masers, evolved stars, variables

1. Introduction

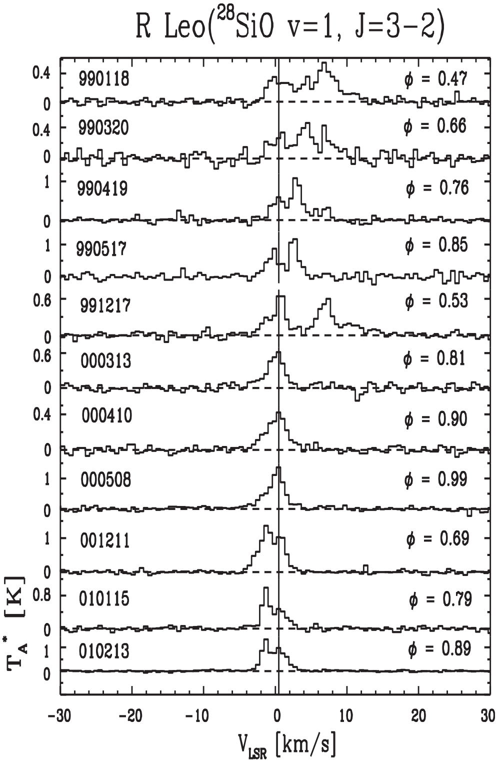
The SiO masers associated with evolved stars are a good probe for investigating the physical processes in the extended atmosphere of these stars. Nowadays, SiO maser emission has been detected in more than 500 evolved stars. However, these observations were mostly focused on J=1-0 and J=2-1 transitions. No systematic observational studies of J=3-2 transition have yet been performed. Therefore, we have performed J=3-2 observations in parallel with J=2-1 observations using the TRAO telescope.

2. Observations

The survey observations of SiO v=0, 1, 2, J=3–2 lines for 42 evolved stars (known SiO J=2-1 maser sources) were performed in 1995, 1996 February (Cho *et al.* 1998), and 1997, 1998 March We used a 124–174 GHz double-sideband Schottky-barrier diode mixer receiver and a 85–116 GHz single-sideband SIS receiver (Han *et al.* 1996). The half-power beamwidths and the aperture efficiencies were about 50″, 37% at 86 GHz and 40″, 33% at 128 GHz, respectively. For simultaneous time-monitoring observations of J=3–2 and J=2–1 masers from 1999 to 2001 (Kang *et al.* 2006), we employed 100/ 150 GHz dual-channel SIS receiver (Park *et al.* 1999). The corrected antenna temperature $T_A{}^*$ is related to the flux density as 1 K $\approx$ 54 Jy at 86 GHz and 1 K $\approx$ 62 Jy at 128 GHz, respectively. A 256 channel x 250 kHz filter bank was used as a main spectrometer. Integration time was 30–60 minutes to achieve 0.05 K rms at 3 σ level.

3. Results

The SiO v=1, J=3–2 maser was detected in 30 evolved stars for the J=3-2 survey observations from 1995 to 1998. The v=2, J=3–2 maser was detected in 9 stars, unlike the anomalously weak emission seen previously in the rare v=2, J=2–1 maser (Cho *et al.* 1998). For the simultaneous time-monitoring observations of J=2–1 and J=3–2 masers towards 10 evolved stars, the line profile and peak velocity variations of SiO v=1, J=3–2



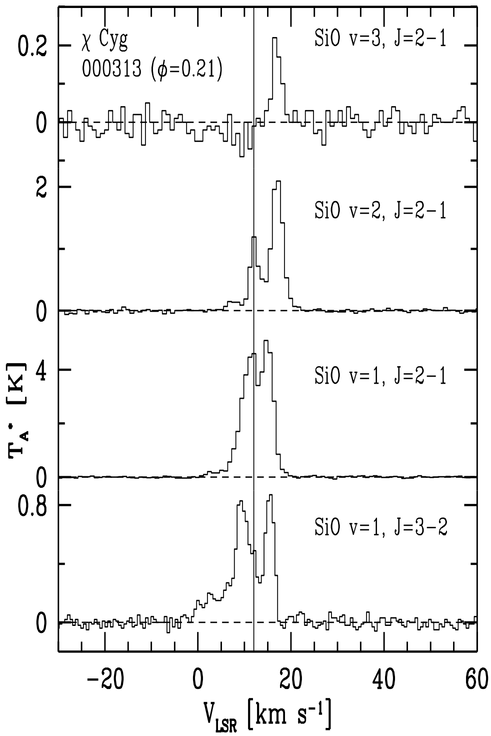


Figure 1. Sample spectra of SiO J=2-1 and J=3-2 masers obtained from time-monitoring observations (Kang *et al.* 2006)

Figure 2. Spectra of χ Cyg obtained from simultaneous observations of SiO J=2-1 and J=3-2 masers (Cho, Lee, & Park 2007)

maser with pulsation phase were different from those of the v=1, J=2–1 maser (Fig. 1). The peak and integrated antenna temperature (PT and IT) ratios between rotational ladders are averaged to be PT(v=1, J=3–2)/PT(v=1, J=2–1) $\approx$ 0.29, and IT(v=1, J=3–2)/IT(v=1, J=2–1) $\approx$ 0.21, respectively (Kang *et al.* 2006). In addition, SiO v=3, J=2–1 maser emission was detected for the first time toward S-type Mira variable χ Cyg as a single spike (Fig. 2). These SiO J=2–1 and J=3–2 results by the 14 m telescope will be a fundamental basis for one key science area for the main observational bands of the Korean VLBI Network (KVN).

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