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NEARLY SIMULTANEOUS OBSERVATIONS OF SiO (v=0, 1, 2, J=3-2) EMISSION IN LATE-TYPE STARS

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ABSTRACT

Nearly simultaneous observations for ^{28}SiO v=0, 1, 2, J=3-2 transitions in 39 late-type stars have been carried out in February 1995 and 1996 with the 14 m radio telescope at Taeduk Radio Astronomy Observatory (TRAO). Observations for ^{28}SiO v=0, 1, 2, J=2-1 lines in the same objects have been also carried out in March 1995 and March-April 1996. The detection rate of ^{28}SiO v=1, J=3-2 line for the ^{28}SiO v=1, J=2-1 sources was 59 %. Seventeen new detections in the ^{28}SiO v=1, J=3-2 transition and 4 new detections in the ^{28}SiO v=2, J=3-2 transition have been reported including the intensity ratios within the vibrational ladders and rotational states.

I. INTRODUCTION

SiO masers associated with late-type stars can be a good probe of stellar atmosphere. Although a relatively large number of SiO transitions have been observed, only the J=1-0 and J=2-1 rotational transitions have been mainly involved so far. After the first detection of ^{28}SiO v=1 J=3-2 maser from Orion KL (Davis et al. 1974), Wolff and Carson (1982) and Schwartz et al. (1982) reported the detection at most several evolved stars. The systematic study of ^{28}SiO J=3-2 maser is not performed yet.

Thus, we have observed a large number of sources in order to provide constraints on models of the pumping mechanism and get an information on the response of the SiO J=3-2 maser regions to the stellar pulsation via statistical study based on nearly simultaneous observations.

II. OBSERVATIONS

Nearly simultaneous observations of the v=0 to 2 J=3-2 lines of SiO were performed in January to February 1995 and February 1996 with the 14 m radio telescope of TRAO, which were made in the frequency of different maser lines by observing an each line within a few days. The half-power beamwidth and the aperture efficiency of the telescope at 128 GHz is estimated to be about 35″ and 0.3, respectively. We used a 125-175 GHz double-sideband Schottky-barrier diode mixer receiver with a horizontally linearly polarized feed; the system noise temperature (SSB) ranged from 600 K to 1000 K for all the observations. The spectra were obtained with a 256 × 250 kHz and 256 × 1 MHz filterbanks. The pointing was checked using a strong SiO J=3-2 sources. The SiO v=0 to 2 J=2-1 line was also observed towards the J=3-2 observed sources with the same telescope. The 3 mm SIS receiver with a SSB system temperature of about 420 K at 86 GHz were used.

III. OBSERVATIONAL RESULTS

In the sample of 39 stars which are relatively bright v=1 J=2-1 sources, SiO v=1 J=3-2 maser emission was detected in 23 stars with 17 new detections, SiO v=2 J=3-2 maser in 7 stars with 4 new detections (TX Cam, R Cas, WX Psc, IK Tau), and SiO v=0 J=3-2 emission in 6 stars. The ^{29}SiO v=0 J=3-2 line was not detected within 3 σ level of 0.07 K. The detection rate of ^{28}SiO v=1 J=3-2 lines for v=1 J=2-1 sources was 59 %. Fig. 1 shows spectra of TX Cam as a representative source with newly detected lines. The main results are summarized as followings.

(1) The average ratio within rotational states of integrated antenna temperature of v=1 J=3-2 line to that of v=1 J=2-1 line for 20 ^{28}SiO v=1 J=3-2 detected Miras is about 0.30, which is much smaller than that ratio of v=1 J=2-1 line to v=1 J=1-0 line, 2 (Schwartz et al. 1979; Spencer et al. 1981; Lane 1982).

(2) The average ratio within vibrational ladders of integrated antenna temperature of v=2 J=3-2 line to that of v=1 J=3-2 line for 5 ^{28}SiO v=2 J=3-2 detected Miras is about 0.34, which is slightly less than half value of the ratio of v=2 J=1-0 line to v=1 J=1-0 line, 0.8 (Schwartz et al. 1979; Spencer et al. 1981; Lane 1982), while the ratio is much larger than the ratio of v=2 J=2-1 line to v=1 J=2-1 line, $< 1/20$ (Clark et al. 1981; Olofsson et al. 1981). But that ratio of integrated antenna temperature I(v=2 J=3-2)/I(v=1 J=3-2) in R Cas, 4.17 and χ Cyg, 11.94 is extraordinarily high.

(3) The dynamical effect of stellar pulsation on SiO J=3-2 masers is not found yet.

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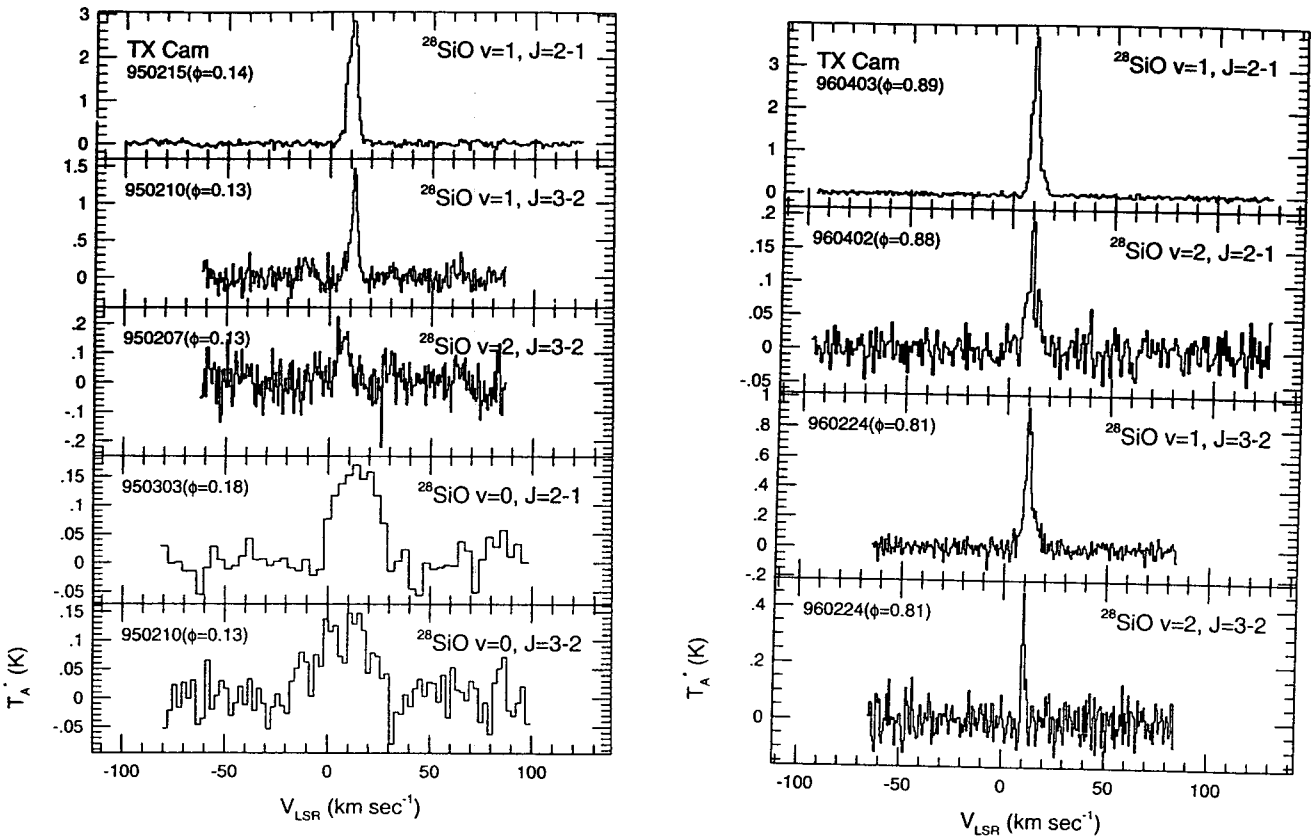

Fig. 1.— TX Cam spectra from both epochs of 1995 and 1996. The ^{28}SiO v=1, 2, J=3-2 lines were newly detected.

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