The 95 GHz Methanol Maser towards the Supernova Remnant Kes 79

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A new methanol maser was detected at 95 GHz (8_0 - 7_1 A^+ transition) towards the supernova remnant (SNR) Kes79. The detected maser is placed in the region of SNR interaction with the ambient molecular cloud. Complex multi-peak form of the spectral line of thermal radiation of CO molecule in maser direction is an evidence of active processes in this region.

Introduction

Supernova explosions are responsible for the propagation of shock waves through molecular clouds. During the expansion the heating of the clouds, the mixing of their matter, the changing of physical conditions and a chemical evolution of these clouds can take place. These possiblities may cause the beginning of processes of active star formation. There are different indicators of such a kind of interaction of the SNR with molecular cloud and one of them is the maser radiation of the hydroxyl molecule at 1720 MHz. Nearly 10 percents of SNRs has these masers in the region of collisional interaction. But there is other type of masers – methanol masers – that have similar conditions to appear. All methanol masers at the present moment are divided into 2 classes accordingly to their pumping mechanism. The II class methanol masers are pumped by radiation whereas the I class methanol masers (at frequencies 85.5 GHz, 95 GHz, 108 GHz) can be pumped by collisions with H_2 molecules. So it is probable for the I class methanol masers to appear in the region of collisional interaction of the shock wave produced by SN explosion with molecular cloud. The 95 GHz methanol maser was chosen for our investigations because it is the strongest maser of the I class masers.

Observations

Observations were performed in November 2004 and October 2007 with the radiotelescope RT-22 of the Crimean Astrophysical Observatory, Simeiz. The halfpower beamwidth of the instrument at 3 mm was 40 arcsec. The effective area of the telescope was 65 sq.m., the root-mean-square pointing error was 12 arcsec. Special complex for maser lines investigations based on Shottky-diode cryogenic receiver was used for observations [1]. System temperature was less than 250 K. The ratio of flux density to antenna temperature was 55 Jy/K at 45 deg declination. The 512-channel Fourier spectrum analyser covering bandwidth of 14 MHz gave us frequency resolution of 27.3 kHz. The standart chopper-wheel technique was used for calibration with respect to the black body with 300 K temperature.

Kes 79

The supernova remnant Kes 79 was chosen for our investigations because of its probable interaction with adjacent molecular cloud. Kes 79 is a shell-type SNR with well defined circular external shell and filamentary external shell. Investigations of the CO and HCO^+ molecules emission from the eastern and south-eastern part of the SNR [2] reveal bright emission from these directions that is the evidence of collisional interaction of this SNR with molecular cloud.

We reveal new methanol maser towards the region of collisional interaction of SNR Kes 79 with molecular cloud at the transition 8_0-7_1 A^+ (95 GHz). The obtained spectrum of maser line is presented in Figure 1. Parameters of this new maser are listed in Table 1. In addition observations of ^{12}CO (J=1-0) emission were made towards the revealed maser position. The complex form of the ^{12}CO (J=1-0) spectral line (Fig. 1) is

the evidence of complicated velocity structure of the molecular cloud in the place of maser formation. The strong evidence of the association of this maser with the region of collisional interaction is proved by the almost exact coincidence of the line-of-sight velocities of the methanol maser line and thermal line of ^{12}CO molecule.

Table 1: Spectral lines parameters, determined from CH_3OH and ^{12}CO observations

Source	α_{2000}	δ_{2000}	$V_{lsr},\ km/sec$	$\Delta V_{lsr},\ km/sec$	$S,\ Jy\ (T_a, K)$
CH_3OH (8_0-7_1 A^+)	$18^h52^m48.05^s$	$+00^\circ\ 40'\ 43.4"$	+88.2	0.62	86.5 Jy
^{12}CO (J=1-0)	$18^h52^m48.05^s$	$+00^\circ\ 40'\ 43.4"$	+87.7	1.26	1.21 K

The interesting fact is that there were several searches for other masers towards this SNR: for water, hydroxyl and 6.7 GHz methanol masers. But all these searches gave negative results [3, 4, 5, 6, 7, 8]. The investigations of 1720 MHz hydroxyl masers take the special position in this list because of these masers as well as 95 GHz methanol masers have the same nature of the pumping – collisional pumping. So they both can be found in the same regions. The curious aspect of this situation is that 1720 MHz hydroxyl masers at the present moment are usually used as one of the tracers of the interaction of SNR's with adjacent molecular clouds [7, 8]. And in our case (Kes79) there were no detections of hydroxyl masers. But there was a detection of thermal radiation of hydroxyl molecule at 1720 MHz from this region [8] and there is a detection of methanol maser. So we assume that regions of collisional interactions of shock waves produced by supernova explosions with interstellar matter have to be rich with Ist class methanol masers and additional investigations have to be carried out to prove or disprove this assumption.

Conclusions

A new 8_0-7_1 A^+ methanol maser was detected towards the SNR Kes 79. There is a strong evidence of the fact that this maser is a result of collisional interaction of this SNR with adjacent molecular cloud. So we assume that I class methanol masers can be used as a tracer of regions of collisional interactions of produced by supernova explosions shock waves with interstellar matter.

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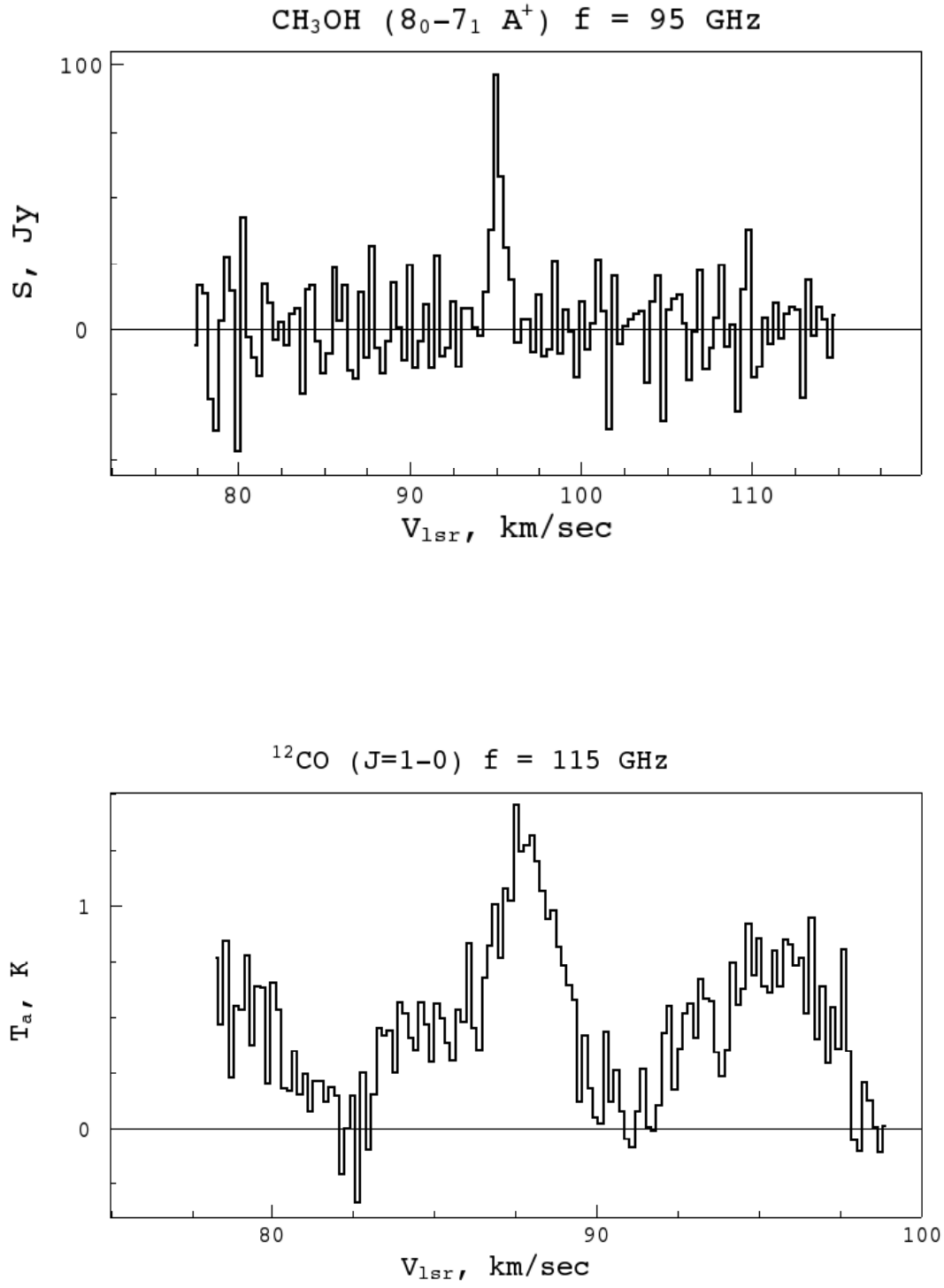

Figure 1: The spectrum of revealed methanol maser and the spectrum of ^{12}CO molecule emission towards the detected methanol maser source.