Methanol Masers Observations in the 3-mm Bandwidth at the Radio Telescope RT-22 CrAO

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We report the beginning of the astronomical masers investigations in the 3-mm bandwidth at the radio telescope RT-22 (CrAO, Ukraine). For this purpose the special complex for maser lines investigation in 85...115 GHz frequency band is developed. It is made on the base of the low noise cryogenic Shottky-diode receiver and the high resolution Fourier-spectrometer. The cryogenic receiver has the DSB noise temperature less than 100K. The spectral channel separation of the Fourier-spectrometer is about 4kHz and the spectrometer bandwidth is 8 MHz. Results of maser observations of 8^0-7^1A^+ transition of methanol (95.169 GHz) towards DR-21(OH), DR-21W and NGC7538 are in good agreement with early obtained results by other authors. On the basis of the analysis of the location of masers in the NGC7538 direction we can assume that the origin of all known class I methanol masers in this region is connected with existing molecular outflows from young stars.

Introduction

Astronomical masers can be named a "point-like probe" of the physical conditions and dynamical processes in places of star burn. A strong interest to the investigation of thermal and maser methanol radiation is caused by the rich methanol spectrum. Multifrequency investigations of methanol masers are of particular interest. Basically such investigations concern just two transitions of methanol molecule 5^1-6^0 E (6.7 GHz) and 2^0-3^{-1} E (12 GHz). Much more interesting are the methanol radiation investigations in the 85...115 GHz frequency band due to 7 transitions revealing maser effect and 4 transitions revealing thermal radiation that can be studied in this frequency band simultaneously. The only simultaneous investigations of all these transitions of methanol were held towards 23 well known high-mass star-forming regions [1] and give a global overview of methanol masers in these directions. This permits us to make conclusions about the relationship of different classes of methanol masers, about the nature of maser sources and about the physical conditions in these star-forming regions.

We report the beginning of methanol masers investigations at the radio telescope RT-22 (CrAO) in 85...115 GHz frequency band.

Complex for maser lines investigations

Special complex for study of maser lines of space sources at the radio-telescope RT-22 was made on the base of high sensitive cryogen superheterodyne 3 mm receiver and three spectrum analyzers. A Fourier spectrum analyzer with high frequency resolution was used in this complex. The block diagram of complex is shown on Fig.1a.

Cryogen receiver presents the cooled part of the complex. The mixer diode chip placed in half-height waveguide. To combine RF and LO signal in receiver diplexer unit is used, whose additional function is 'cleaning' the LO spectrum. The LO is PL L synthesizer with BWT OB-71. Cooled IF amplifier is designed at IRA NASU, used 2 PHEMT transistors 'Agilent' and provides gain more than 20dB and noise temperature less then 2K under 20K ambient temperature [2]. Diplexer, mixer and IF amplifier were placed in the cryoblock and cooled up to 20K with a help of closed circle criogenic cooler. Noise temperature of receiver was measured in laboratory and its value (T_N^{DSB}) was less then 100K at any frequency in the 85...115 GHz band (see Fig. 1b).

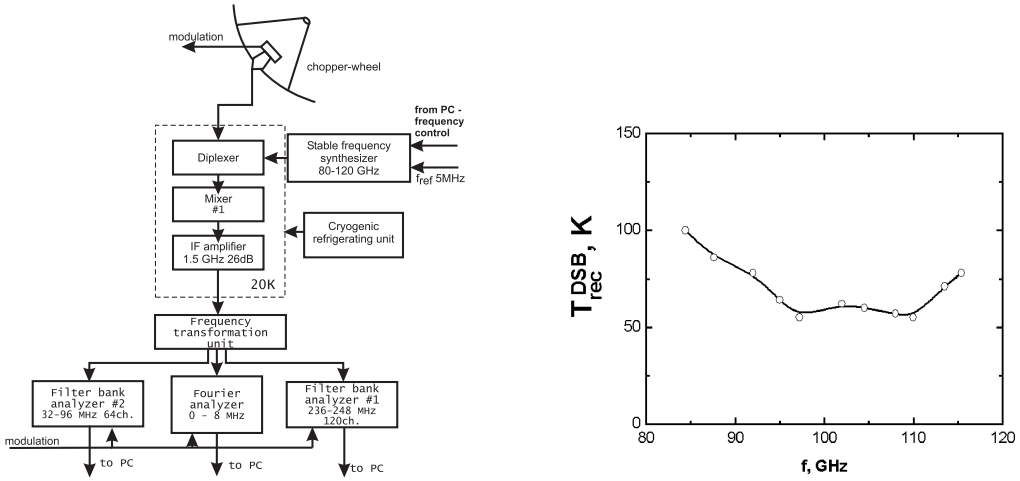

Figure 1: The block diagram of the complex for maser lines investigations (a) and the noise temperature of the cryogenic receiver in the frequency band 85...115 GHz in the DSB regime (b).

Uncooled part of the complex is used for amplification of received signal on intermediate frequency and for coupling with 2 types of spectrum analyzer. One of them is filter bank spectrum analyzers with low frequency resolution. It increase the frequency band of the complex up to 12 MHz. Fourier analyzer can operate in 2 regimes and provides our complex with high frequency resolution (3.9 kHz).

Methanol masers observations.

Observations were carried out on November, 2004 at the 22m radio telescope RT-22 (CrAO, Simeiz). The effective area of the radio telescope was estimated with planets (Jupiter, Venus) observations and at 95 GHz it was 65 m^2. The main beam width of the radio telescope was estimated from the planet observations and was $40''$. The root-mean-square pointing error of the radio telescope was $1''$.

During the observations three maser sources were detected towards NGC7538, DR21(OH), DR21W. The results of observations are presented in Table 1 and they are in good agreement with earlier results retrieved by other authors [3, 4].

Table 1: Line parameters, determined from CH_3OH 8^0-7^1A^+ masers observations

Source	α_{2000}	δ_{2000}	V_{lsr}, *km/sec*	ΔV_{lsr}, *km/sec*	*S, Jy*
NGC7538	$23^h13^m46.5^s$	+61° 27' 32.7"	-57.44	0.75	21
DR21(OH)	$20^h38^m59.2^s$	+42° 22' 48.7"	+0.16	0.73	136
DR21-W	$20^h38^m54.6^s$	+42° 19' 23.5"	-2.69	1.18	52

DR21(OH) and DR21W.

We detect maser sources towards DR21: DR21(OH) and DR21W. The observed spectra are shown in Fig. 2. This maser sources were earlier detected on the BIMA by the authors of [3] and their line width were twice narrower than in our observations. This fact in the case of DR21(OH) can be explained by the simultaneous observations of two masers DR21(OH)-1 and DR21(OH)-2 [3] , that can be resolved during interferometric observations and can not be resolved on a single-dish telescope. The earlier observations of this maser sources on a single-dish telescope [4] reveal the same maser line parameters as in our observations.

NGC7538.

NGC7538 is an HII region and a young-stars rich cluster. There are 11 IR sources (marked IRS1-11) towards. Moreover 2 bipolar outflows from IRS1 and IRS11 can be seen in this region during CS and CO

observations [5]. Several 44 GHz methanol masers were found in this region [6]. The map of these outflows is shown in Fig. 3, also here are all 44 GHz and 95 GHz methanol masers towards this direction. It can be seen, that 44 GHz and 95 GHz methanol masers are placed between blue-shifted wing of the outflow from IRS11 (-64...-62 km/sec) and red-shifted wing of the outflow from IRS1 (-45...-40 km/sec). The both radial velocities of detected 95 GHz methanol maser (-57.44 km/sec) and of detected 44 GHz methanol masers (-56.6...-59.2 km/sec) agree with radial velocities of methanol thermal lines at 133 and 157 GHz in this direction (-57.1...-58.7 km/sec) [7].

As long as both 95 and 44 GHz masers belongs to masers with collisional pumping [8] and their velocities sufficiently good agree with velocities of the wings of the outflows presented here we assume that these masers originate from interaction of these outflows and molecular cloud.

Conclusions.

With the low noise cryogenic Shottky-diode receiver and high resolution Fourier-spectrometer the high sensitive complex for maser lines investigations with frequency resolution 3.9 kHz in 85...115 GHz frequency band at the radio telescope RT-22 (CrAO) was developed and first observations were carried out.

Relying on the results of observations of methanol masers towards NGC7538 we assume that all class I methanol masers in this direction originate from the interaction of existing here bipolar outflows from IR sources IRS1 and IRS11 with molecular cloud.

References

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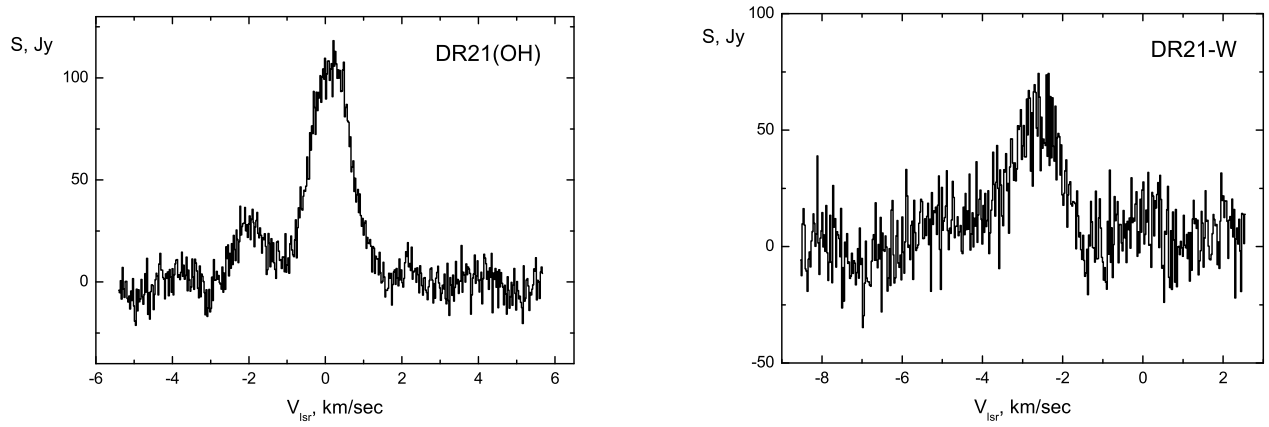
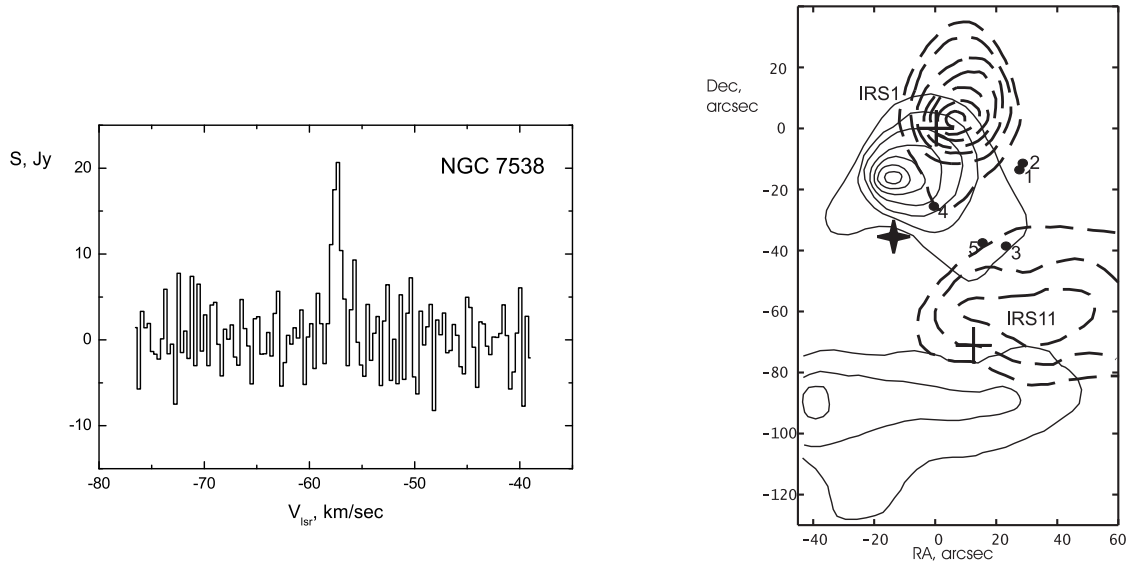


Figure 2: Spectra of maser sources towards DR21(OH) and DR21W.



a. b.

Figure 3: The spectrum of the maser source towards NGC7538 (a) and the map of the molecular outflows from IRS1 and IRS11 towards NGC7538 in CO-line [5] with class I methanol masers (7^0-6^1A^+ (44GHz) masers [6] are marked with black circles, with a star marked the detected maser 8^0-7^1A^+ (95GHz)) (b). IR sources IRS1 and IRS11 are marked with crosses. Red- and blue-shifted wings of outflows are marked with solid and dashed lines accordingly. Position (0, 0) of the map corresponds to the position of IRS1 ($23^h13^m45.5^s$, $+61^\circ 28'$ 09", J2000)