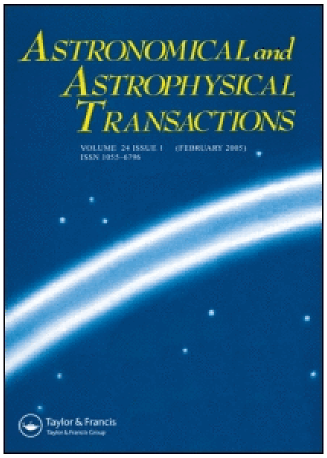

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Spectral observations of OH and water maser sources at the Crimean Astrophysical Observatory with the RT-22 radio telescope

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Observations of almost all know cosmic masers from decimetre to millimetre wavebands have been performed at the Radio Astronomy Laboratory of the Crimean Astrophysical Observatory with the 22 m radio telescope RT-22. Modernization of existing receivers was performed and also receiving systems were created with maximum possible sensitivities in new frequency ranges that were selected from observations of the least studied maser sources with the 5 GHz room-temperature and cryoelectronic radiometers in the single-antenna mode; observations of star-forming regions were conducted using the spectral line of the OH molecule at a frequency of 4765 MHz with a spectral resolution of 0.06 km s^{-1}. The observations of stars of early and late spectral classes were conducted, and spectra were obtained using the spectral lines of water vapour and the OH molecule at frequencies of 1612, 1665, 1667 and 1720 MHz with a spectral resolution of 0.02 km s^{-1}. In addition, utilizing the 22 GHz cryoelectronic receiver in the single-antenna mode, spectral observations of star-forming regions were conducted, and spectra obtained for the spectral line of water vapour.

Keywords: Star-forming regions; Maser sources; Observations; Radiometers

1. Observations and results

Observations of the spectral lines of OH and water molecules of sources of maser emission were performed at the Radio Astronomy Laboratory of the Crimean Astrophysical Observatory with the 22 m radio telescope. Both cooled and non-cooled receivers with high-electron-mobility transistor low-noise amplifiers were used and provided the noise temperatures of the receiving systems: $T_{sys} = 30$ K at a frequency of 1.6 GHz (non-cooled), $T_{sys} = 10$ K at a frequency of 4.8 GHz (cryoelectronic), $T_{sys} = 30$ K at a frequency of 4.8 GHz (non-cooled), $T_{sys} = 22$ K at a frequency of 22 GHz (cryoelectronic) and $T_{sys} = 120$ K at a frequency of 22 GHz (non-cooled). In the development of traditional observations at which the emission of ground-state $^2\Pi_{1/2}$ OH molecules (at frequencies of 1.612, 1.665, 1.667 and 1.720 GHz) was

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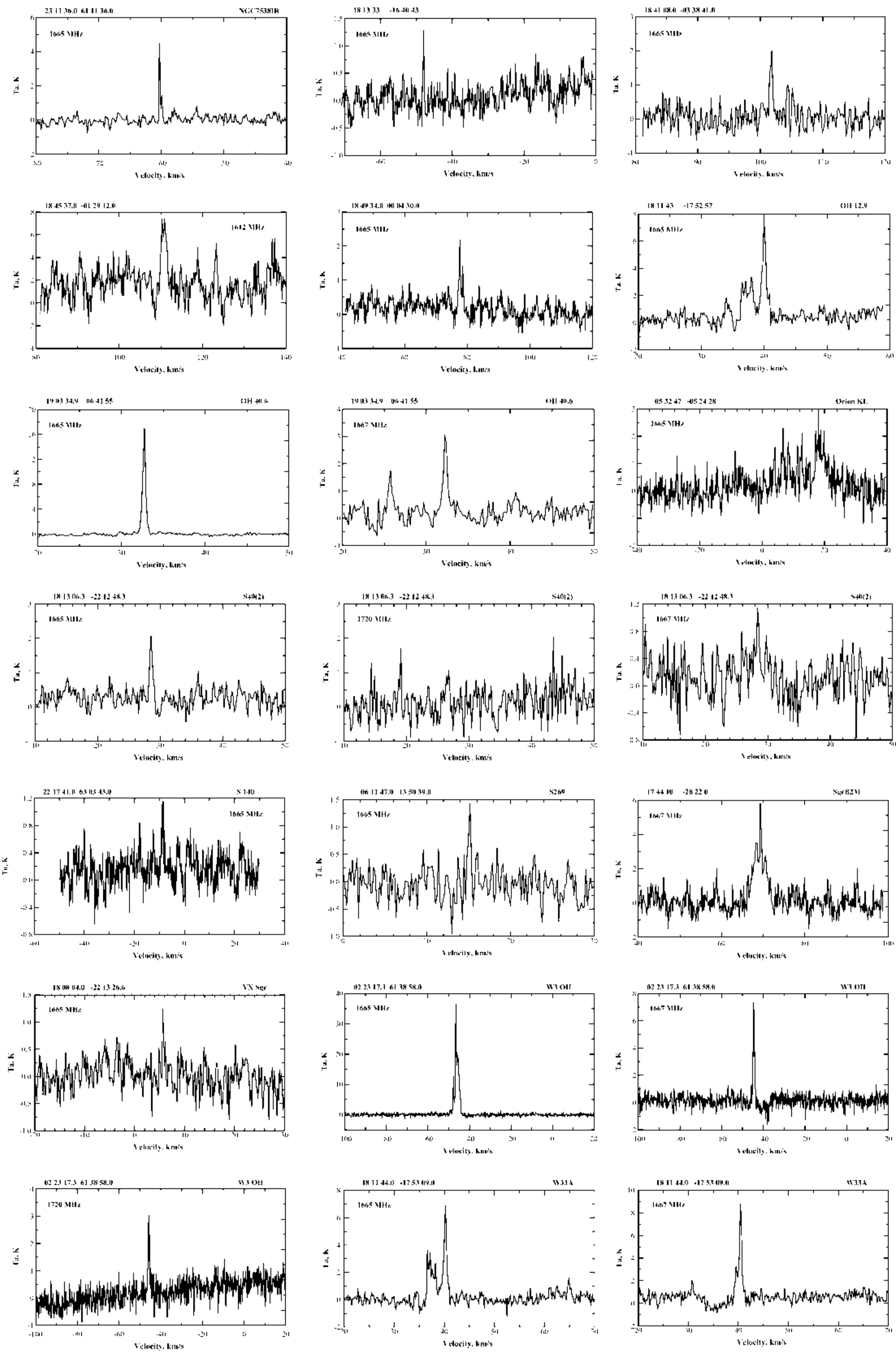

Figure 1. OH maser sources at a wavelength of 18 cm on 10–20 July 2005 ($F/T_a = 12.8\,\mathrm{Jy\,K^{-1}}$).

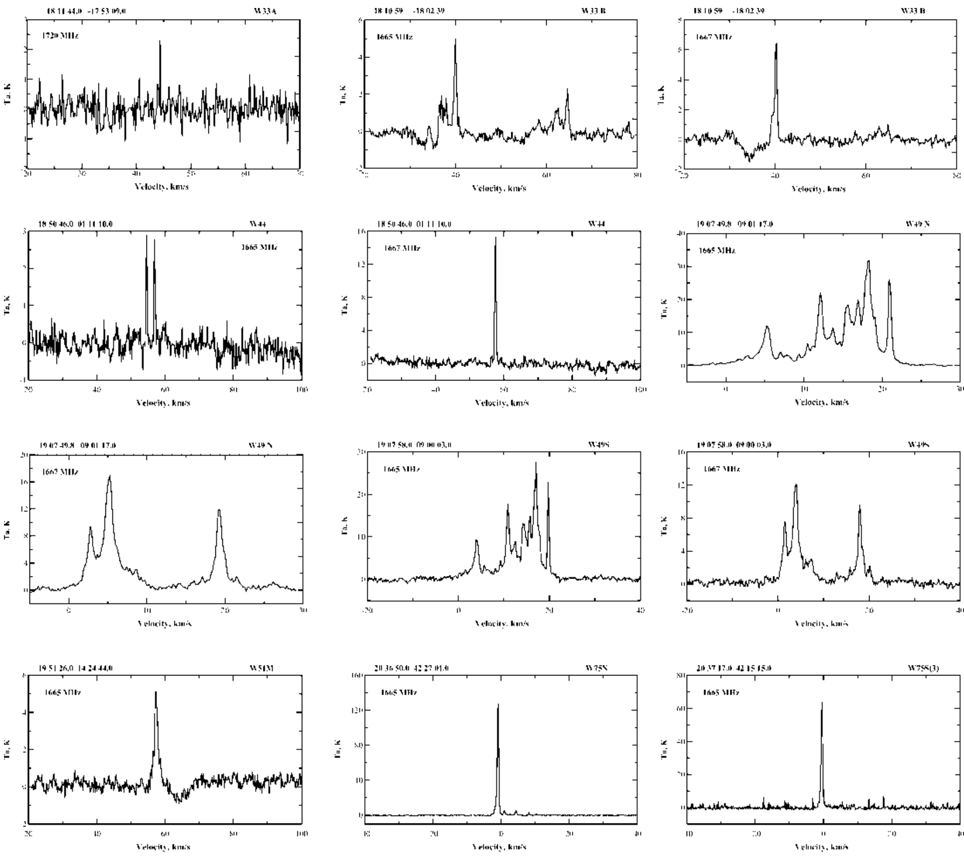

Figure 1. Continued.

studied, the creation of a receiver for a frequency of 4.8 GHz allows us to study transitions of the $^2\Pi_{3/2}$ energy state.

1.1 *OH molecule maser emission sources at a wavelength of 18 cm*

OH maser sources at a wavelength of 18 cm are unique objects of the interstellar medium. They have very small angular sizes, and their emission with a relatively high intensity is observed in a very narrow frequency band. They are characterized by variations in the intensity and polarization of their emission which indicates non-stationarity of the emission mechanisms. Statistical studies of the temporal behaviour of sources of OH maser lines revealing the possible trends and relationships are essential for investigating star formation processes. In May-July 2005, observations of more than 100 star-forming regions with the spectral line of the OH molecule at frequencies of 1612, 1665, 1667 and 1720 MHz were conducted with the new radiometer. Figure 1 shows the results of observations related to the maser sources associated with stars of early spectral classes (the so-called starless maser sources) and related to the maser sources associated with stars of late spectral type (the so-called star-like maser sources) in the neighbourhood of which the OH maser emission was observed. The velocity in kilometres per second is plotted on the horizontal axis; the antenna temperature in kelvins is plotted on the vertical axis. Above every plot the coordinates (1950) and name of the source are indicated.

Table 1. Maser sources observed at a frequency of 4765 MHz.

Name	Right ascension (1950) (h min s)	Declination (1950)	Velocity (km s^{-1})
W3(OH)	02 21 55	61° 52′ 00″	−44.0
Orion-IR	05 32 47	−05° 24′ 20″	13.1; 17.6
Mon R2	06 05 19	−06° 22′ 50″	10.8
S252-A3	06 05 34	20° 39′ 47″	9.8
Sgr B2	14 44 10	−28° 22′ 02″	59.5
OH353.41-0.36	17 27 06	−34° 39′ 10″	−20.7
W49 N	19 07 48	09° 01′ 14″	2.1
W51 Main	19 21 24	14° 24′ 40″	57.3
K3-50	19 59 52	33° 24′ 20″	−20.4
ON1	20 08 10	31° 22′ 41″	9.5; 24.1
DR 21(OH) N	20 37 14	42° 14′ 08″	−3.2; 5.1
W75 S(1)	21 41 21	54° 42′ 30″	−62.1
NGC 7538	23 11 36	61° 11′ 49″	−59.2

1.2 *Sources of OH molecule maser emission at a wavelength of 6 cm*

Observations at wavelengths near 6 cm (the frequency is about 4.7 GHz) allows us to study maser emission in the transitions related to the energy state $^2\Pi_{3/2}$ of the OH molecules. The intensity of maser emission in these transitions is many times weaker than the emission in the transitions related to the ground state $^2\Pi_{1/2}$ and is observable at a wavelength of 18 cm. The number of observed sources at frequencies around 4.7 GHz does not exceed about 30. The radio telescope RT-22 is equipped with new receivers at a frequency of 5 GHz with the use of a non-cooled low-noise radio-frequency transistor amplifier made by Saturn. The front-end low-noise amplifier with converters to intermediate frequencies and with a phase-locked heterodyne receiver are located at the primary focus of RT-22. The parameters of the radio telescope-radiometer system were measured in the single-antenna mode.

In the period 2003–2005 with the use of the new non-cooled radiometer, four sessions of observations of star-forming regions with the spectral line of the OH molecule at a frequency of 4765 MHz were conducted. In table 1 the observed maser sources are indicated.

Figure 2 shows the emission of the Mon R2 source. In February–March 1982, for the Mon R2 source, the intensity of the component with a radial velocity of 10.8 km s^{-1} was about

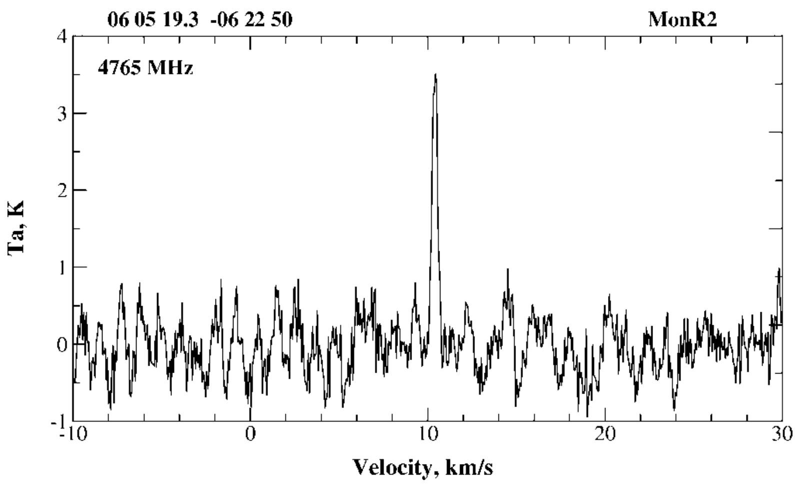

Figure 2. The emission of the Mon R2 source on 23 July 2005 ($F/T_a = 13.2$ Jy K^{-1}).

0.12 Jy. In October 1990 and in March 1991, the values were 1.5 and 0.5 Jy, respectively. In October 1994, the flux increased to 3 Jy and, by the end of 1994, it had risen to a value of 7–8 Jy. In the middle of 1995, the flux density increased to 30 Jy and then began to drop. In the middle of 1997, the flux density of this component reachd 75 Jy and, in the second half of 1998, it decreased to 5 Jy. Our data show an increase in the intensity of the maser line of about ten times in comparison with the data from observations in the second half of 1998.

1.3 *Maser sources of water molecule*

Before 2000, observations of maser sources with the spectral line of water vapour at a wavelength of 1.35 cm were conducted utilizing the apparatus used in the very-long-baseline interferometry observations [1]. In 2000, a spectral-polarimetric receiver for automated observations was developed and put into operation. The spectrum profile of the explored source was determined by the change in the frequency of the third heterodyne receiver, i.e. by

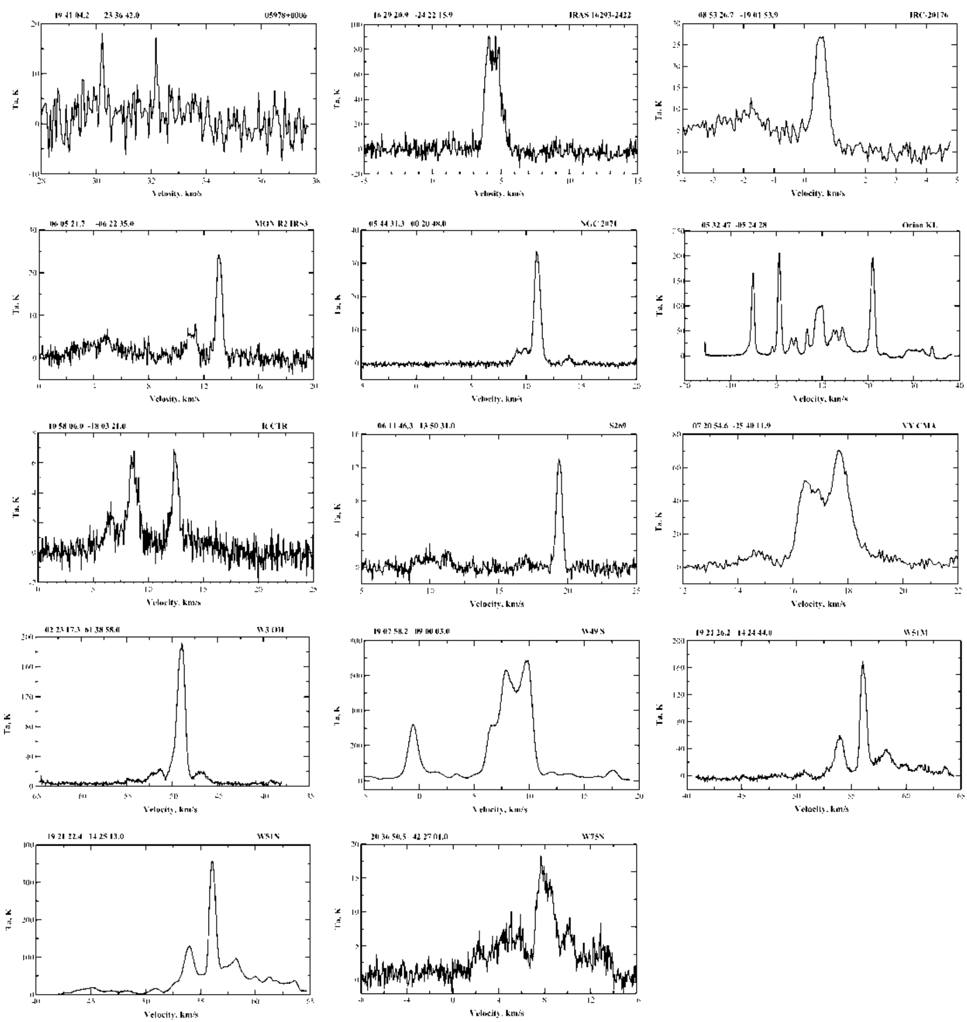

Figure 3. Water maser sources on 18–25 September 2002 ($F/T_a = 13.8\,\text{Jy}\,\text{K}^{-1}$).

displacement of the reception band in frequency steps of 10 kHz, with subsequent recording of the dependence of the output signal on the frequency [2]. Since 2002, a cryoelectronic radiometer at a frequency of 22 GHz and a Fourier spectrum analyser of parallel type (made at the Radio Astronomical Institute, National Academy of Sciences of Ukraine) were developed and put into operation; this substantially improved the frequency resolution and enabled us to conduct systematic and complex research studies of the regions of star formation [3–5]. Figure 3 shows the spectra of the water vapour maser source at a wavelength of 1.35 cm.

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