AGREED	**APPROVED BY**
Director of the SAO RAS,	**Chairman of the Russian Telescope Time Allocation Committee,**
V.V. Vlasyuk	**K.A. Postnov**
“ ” ___________2020	**“ ” ___________2020**

Circular Letter of the Russian Telescope Time Allocation Committee

The following radiometric complexes are being announced for use at the radio telescope RATAN-600 of the Federal State Budgetary Institution of Science of the Special Astrophysical Observatory of the Russian Academy of Sciences (SAO RAS) since the second half of 2020:

1. Radiometers continuum complex at the frequencies range of 1.25-22.3 GHz (1.25, 2.25, 4.7, 8.2, 11.2 and 22.3 GHz) with bandwidths from 4% (at dm wavelengths) up to ~10-12% (at cm wavelengths) relative to the central frequency with the secondary mirror № 1
2. Radiometers continuum complex ERIDAN at the frequencies range of 2.25-22.3 GHz (2.25, 4.7, 11.2 and 22.3 GHz) with bandwidths from 4% (at dm wavelengths) up to ~10-12% (at cm wavelengths) relative to the central frequency with the secondary mirror № 2.
3. Multibeam radiometric complex at 4.7 GHz frequency range for the fast radio bursters (FRB) searching with the secondary mirror № 5.
4. Solar spectral-polarization complex at the frequencies of 3-18 GHz with the secondary mirror № 3.

A brief description of radiometric complexes and the corresponding observational methods implemented at the RATAN-600 can be found below. Detailed information can be found in the library of the SAO RAS or at the home page of the observatory, http://www.sao.ru in the user manual section.

1. Radiometers of the continuum of the range 1.25-22.3 GHz (1.25, 2.25, 4.7, 8.2, 11.2 and 22.3 GHz) with bandwidths from 4% (at dm wavelengths) up to ~10-12% (at cm wavelengths) relative to the central frequency with the secondary mirror № 1. **Method 1: the spectral flux density measurement at the frequency range of 1.25-22.3 GHz.**

2. Radiometers continuum complex ERIDAN at the frequencies range of 2.25-22.3 GHz (2.25, 4.7, 11.2 and 22.3 GHz) with bandwidths from 4% (at dm wavelengths) up to ~10-12% (at cm wavelengths) relative to the central frequency with the secondary mirror № 2. **Method 2: the spectral flux density measurement at the frequency range of 2.25-22.3 GHz.**

3. Multibeam radiometric complex at 4.7 GHz frequency range for the fast radio bursters (FRB) searching (secondary mirror № 5). **Method 3: the spectral flux density measurement at the frequency range 4.4-5.0 GHz with a high temporal resolution (up to 62.5 µs).**

Responsible person for the methods 1-3: the continuum radiometers laboratory: N.A. Nizhelsky (nizh@sao.ru), P.G. Tsybulev (peter@sao.ru).

Technical features. The current level of the detecting equipment of the RATAN-600 radio telescope is provided by the ultra-low-noise, uncooled amplifiers with high electron mobility transistors (HEMT) and digital signal processors in the data acquisition system.

The standard radiometers parameters are presented in the Tables 1a, 1b and 1c. Designations: f_0 – central frequency (GHz); Δf_0 - bandwidth (GHz); ΔF - sensitivity by the spectral flux density per unit of the resolution element (mJ/beam); BW is the width of the diagram for declination $\delta \sim 42°$; AR - angular resolution for medium altitudes; BW – width of the beam pattern for medium altitudes (δ~42°).

The RATAN-600 continuum radiometers are the direct receivers of the microwave signals in the given frequency bandwidth square-law detection for obtaining the output signal. The operating mode of all the receivers is "total power radiometer". The data is collected using a regular universal registration system based on the new hardware-software subsystem ER-DAS (Embedded Radiometric Data Acquisition System) [1].

Table 1a. The broadband receiver's parameters for the six-frequency complex (secondary mirror №1).

f_0 (GHz)	Δf_0 (GHz)	ΔF (mJy/beam)	BW sec	AR arcsec
22.3	2.5	50	1.0	11
11.2	1.4	15	1.4	15.5
8.2	1.0	10	2.0	22
4.7	0.6	5	3.2	35
2.25	0.08	40	7.2	80
1.25	0.06	200	10	110

Table 1b. The broadband receiver's parameters for the ERIDAN complex (secondary mirror №2).

f_0 (GHz)	Δf_0 (GHz)	ΔF (mJy/beam)	BW sec	AR arcsec
22.3	2.5	95	1.5	16.5
11.2	1.0	30	2.1	23
4.7	0.6	10	4.8	53
2.25*	0.08	80	11	121

* - test regime due to electromagnetic interference;

Table 1c. Multibeam radiometric complex characteristics (secondary mirror №5).

B (GHz)	Δf (MHz)	ΔF (mJy/beam)	$HPBW_x$ (sec)	AR (arcsec)
4.40-4.55	150	10	3.2	35
4.55-4.70	150	10	3.2	35
4.70-4.85	150	10	3.2	35
4.85-5.00	150	10	3.2	35

Table 1c comments: the wide band of 600 MHz of each radiometer is divided into 4 "narrow" subbands of 150 MHz. A quadratic detector is installed at the output of each "narrow" channel. The data are recorded in the "Total power radiometer" (TPR) mode, so the radiometric complex consists of 16 independent radiometers. Dividing the 600 MHz band into 4 sub-bands allows you to measure the dispersion of radio waves in an interstellar medium. The presence of such dispersion is a sign of a distant radio source (and not local interference). Signals are recorded using a standard data acquisition system with a frequency of 16384 counts per second for each of the 16 channels. Four radiometers on the Western sector of the RATAN-600 antenna allow you to observe 4 adjacent parts of the sky simultaneously, thereby expanding the view field 4 times. The observations are carried out in the survey mode, in the form of hourly one-dimensional scans at a fixed declination. At the beginning of 2020 the Western sector height corresponds to the microquasar Cyg X-3 declination. The Method 3 can be implemented jointly and in agreement with the SAO RAS methods responsible person only.

Antenna parameters. The angular resolution of the radio telescope depends on the height of the antenna installation. Its value by declination is three to four times worse than in the right ascension, due to the knife-shaped beam pattern. The detection limit of the radio telescope is about 8 mJy (accumulation time 3 sec) at 4.8 GHz at medium angles under good weather conditions.

The radio telescope RATAN-600 is a radio telescope with an antenna of a variable profile [2-7]. RATAN-600 is a reflector type radio telescope with an antenna of a variable profile [2-7], that is, both the aperture and focal length of its antennas change depending on the elevation of the object. The elevation of the antenna varies from 3.5° to 97°. The focal length varies from 155 m to -40 m (from the center of the circle). At the same time, the aberration zone in the focus of the secondary mirror changes significantly: the greater the focal length, the less the focal image of the source is distorted. Such features of the RATAN-600 antenna geometry allow measuring the flux densities of the source in the same antenna position in the frequency range from 1.25 to 22.3 GHz for 1-2 minutes. Independent observations can be carried out on two antenna sectors in three configurations: the Northern sector, the Southern sector, the Southern sector with a Flat reflector. The following declination ranges are available:

(i) Northern sector: -42°<DEC<+50° (it is necessary to use the "fixed" focus mode at low declination).

(ii) Southern sector:
in the upper culmination: +72°<DEC<+90°,
in the lower culmination: +49°<DEC<+90°.

(iii) Southern sector with a Flat reflector: -42° <DEC <+71°. Objects with DEC>71° can only be observed in the mode from item (ii).

Observations with the Northern sector are carried out with the radiometric complex of the secondary mirror №1. Observations with the Southern sector and the Southern sector with a Flat reflector are performed on radiometric complexes of secondary mirrors №2 and №3 (see the methods 2 and 4, respectively).

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4. Solar spectral-polarization complex at the frequencies of 3-18 GHz with the secondary mirror № 3.
Method 4: The radio emission intensity and polarization measurement of the discrete radio sources and the Sun in a dynamic range up to 60 dB at the frequencies 3-18 GHz.
Responsible for the method 4: the Radio astronomy research laboratory, A. Storozhenko (asc-work@mail.ru).

The functionality of the complex is related with a significant increase in the dynamic range for the purpose of registering reference sources in the microwave waveband at the levels of both the limiting sensitivity for this instrument and for recording the brightest radio sources on the Sun reaching millions of degrees of the antenna temperature. This is achieved by the introduction of automatic attenuators on the signal amplification lines across all channels of the complex. The complex can be used for a variety of antenna measurements, as well as for powerful signals from geostationary satellites. The complex was installed in 2016 in the RATAN-600 receive cabin № 3, which is working at the southern sector antenna system with a Periscopic reflector for conducting multiple observations of the dynamics of the Sun in azimuths and in tracking modes.
A full power mode of the receivers with registration of right and left circular polarizations on all channels is realized.
All necessary features of the complex during the observations, such as the rapid analysis and full reduction of observations are also realized in the automatic mode. The format of the observational data is consistent with the observational database existing since 1995.

Parameters of the complex:
Frequency range: 3.0 GHz – 18 GHz;
2 levels of frequency resolution: 1st level: 80 channels, bandwidth of 100 MHz,
2nd level: 10 channels, bandwidth of 1500 MHz;
Registration speed: 0.0025 sec/112 channels;
Noise temperature: 300 K;
Dynamic range:> 60 dB;
Inter-channel decoupling:> 20 dB;
Ellipticity: (1-5)%;
The width of the horn diagram in the entire range: +-60 degrees;
The decoupling between the RH and LH polarizations:> 20 dB;
The offset of the phase centers for RH and LH: 0.5 mm.

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