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PROSPECTS OF SOLAR MICROWAVE OBSERVATIONS AT THE VENTSPILS RADIO-ASTRONOMY CENTER

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The paper concerns the prospects, technical issues and unique possibilities of solar microwave observations using the RT-32 radio telescope of the Ventspils International Radio-Astronomy Center. The solar physics tasks are discussed that are to be solved based on the observations of the large-scale coronal structures and radio flux fluctuations of as well as the magnetic structure of solar active regions.

1. INTRODUCTION

Since 1998, when first trial astronomical observations were carried out using the renewed 32-m radio telescope (further in the text RT-32) of the Ventspils International Radio-Astronomy Center (VIRAC) [1], a series of arrangements for the solar microwave observations have been undertaken. Figure 1 shows two radio maps of the Sun obtained using the RT-32 at the wavelength of 2.7 cm in September 2002.

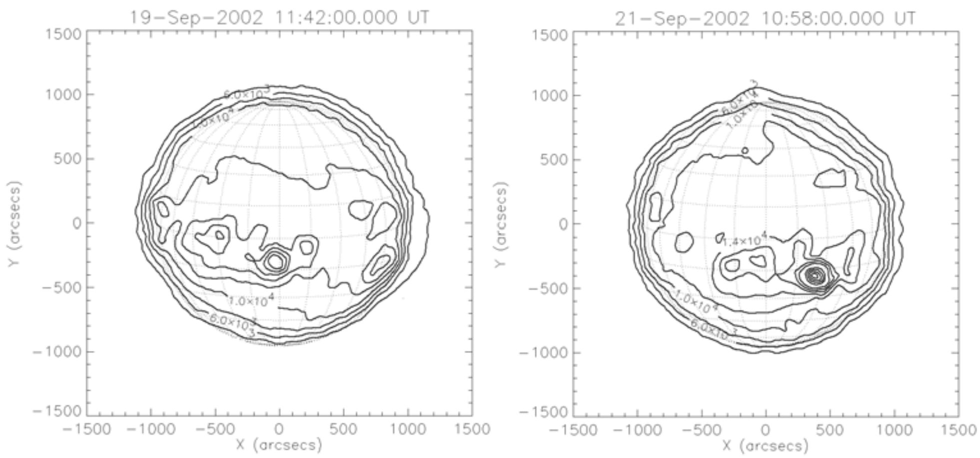

Fig. 1. Radio maps of the Sun acquired with the RT-32 at 2.7 cm (September 19 and 21, 2002).

The geographical position of the RT-32 (E 21^{o}51’17’’, N 57^{o}33’12.3”) − more western compared with two radio interferometers, namely, the Siberian Solar Radio Telescope (SSRT) operating at 5.2 cm and the Nobeyama Radio Heliograph (NoRH) operating at 1.76 cm and 0.88 cm (Fig. 2) supplying the main volume of worldwide solar microwave observations − is one of the advantages of the telescope. A full-day observational schedule of the RT-32 is suggested to cover the unused time intervals of the two mentioned radio-telescopes.

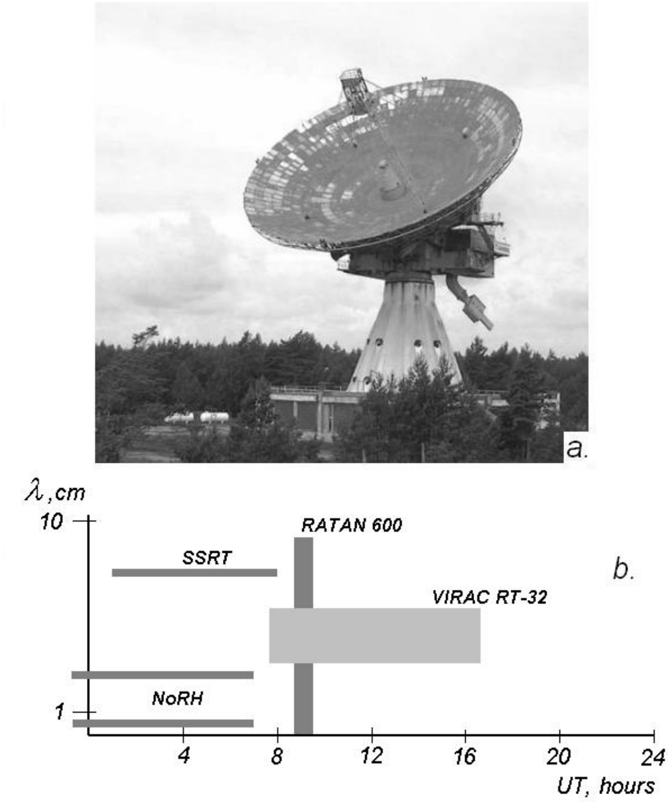

Fig. 2. The 32-m radiotelescope of the VIRAC (*a*). The operational wavelength range of other radio telescopes and the available time for RT-32 solar microwave observations (*b*).

2. SOLAR SPECTROPOLARIMETER

The spectropolarimeter of the RT-32 (Fig. 2 *a,b*) has been made at the Special Astrophysical Observatory of the Russian Academy of Sciences. Being equipped with a spiral antenna feed, it is expected to be used for solar microwave observations − in particular, the circular polarizations and the total intensity in the wavelength range 3.2–4.7 cm (6.35–9.35 GHz). This band is divided into 16 sub-bands with a bandwidth of 120–140 MHz each, uniformly shifted towards 200 MHz (Fig. 3*c*).

The spectropolarimeter consists of two similar UHF units, an IF multiplexor, a set of frequency filters, an analog-to-digit converter and an Ethernet controller. The observer can exert control over the spectropolarimeter using the local network, with a sample rate up to 80 samples per second.

The set of operating frequencies is specific: the difference of any two adjacent frequencies is constant (200 MHz), with the relation (0.81 ± 0.01) nearly constant for two successively paired frequencies in two bands (6.35–7.70 and 7.97–9.33 GHz) of the spectropolarimeter. This will allow for a reliable analysis of both bremsstrahlung and gyro-resonance radiation.

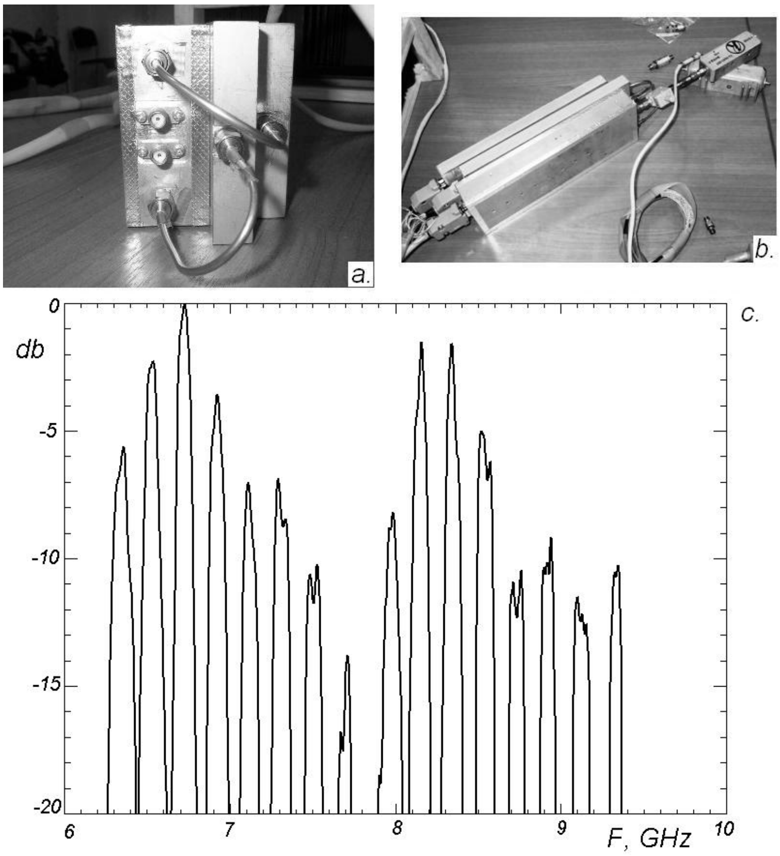

Fig. 3. The 16-channel spectropolarimeter for the 3.2–4.7 cm wavelength range. (*a,b*).
The comparative sensitivity characteristics at the employed frequencies (*c*).

3. PROBLEMS TO BE SOLVED

To carry out the full-scale solar observations with the RT-32, the following problems should be solved:

- provision of the routine works for the antenna adjustment & calibration and for studying the properties of antenna;
- full automation of the solar radio-observation process;
- development of suitable methods for the synthesis of a 2D radio map and elimination of its aberration caused by the RT-32 antenna;
- organization and support of a “raw” and processed data multilevel archive available to any investigator.

The solar observations group of the VIRAC is developing some numerical techniques (CLEAN and MEM) to eliminate the telescope’s aberrations [2] as well as to simulate the generation and propagation of microwaves in the solar atmosphere [3].

The main flaws of the spectropolarimeter and antenna that limit the observational potential of RT-32 are:

- the system's temperature (100–120 K);
- the HPBW of the antenna pattern (3.4–5.1 arcmin);
- the hardware time constant (0.1–0.2 s).

Taking into account these limitations, we are now preparing a tentative list of some feasible tasks for solar microwave observations with the RT-32 (the list is supposed to be open).

The expected data flows from the RT-32 are of the type:

- 16 total intensity microwave maps and 16 circular polarization maps simultaneously acquired from an automated solar disk stripping;
- runs of total radio flux I and circularly polarized flux V in each of the 16 channels as a result of tracking a selected local source on the Sun;
- optional types:
    - time profiles of any noticeable microwave radio burst that has occurred when tracking a local source;
    - runs taken during the tracking of microwave local sources at the time of a solar eclipse;
    - 2D maps of a quiet Sun (as the basic feature of solar maps).

In view of the technical properties and possibilities provided by the RT-32 we propose the following list of feasible tasks:

1) Observations of large-scale coronal structures in the microwave range

1.1. Search for radio brightness of coronal holes and the quiet Sun through the microwave range [4].

The subject of investigation is the variation of the brightness contrast within a microwave range [5] as a result of deeper penetration of microwaves into the rarefied plasma of coronal holes. To verify this hypothesis it is planned to study the detailed structure of solar atmosphere based on simulations of the microwave propagation.

1.2. Revealing and analyzing the large-scale coronal loops as immediate relatives of distant active regions (ARs) so as to reproduce sympathetic solar flares [6].

It is expected that the microwave emission of some coronal loops could be discerned in a close proximity of the mutually linked together ARs. Of interest is also the correlation between the sympathetic flares and the microwave characteristics.

2) Observations of radio flux fluctuations in local microwave sources

2.1. Analysis of the radio flux fluctuations resulting from the magnetic field emergence in ARs [7].

By tracing a newly emerging magnetic flux at a sunspot we can observe radio flux fluctuations, e.g. those stemming from the irregular character of the magnetic field emergence. Based on spectra-polarization observations, the analysis of these fluctuations could provide valuable information on the atmospheric layers passed by an emerging flux.

2.2. Analysis of the radio flux fluctuations preceding a solar flare.

When tracing a large AR, which tends to fluctuate in the microwave range [8], the onset and power of a solar flare can correlate with characteristics of the fluctuations.

3) Coronal magnetography

3.1. Transformation of microwave maps of the Sun to those of the coronal magnetic fields.

To recalculate the microwave maps to those of the coronal magnetic field strength the properties of generation and propagation of microwaves in a solar corona are employed [9]. The well-localized coronal layers of microwave generation (e.g. gyroresonance levels) as well as microwave propagation (e.g. the region of quasi-transverse propagation) are of especial interest.

4. CONCLUSION

The preparatory work has been done to approach, based on the radio observations of the Sun with the telescope RT-32, solution of such problems of solar physics as the large-scale coronal loops (being immediate relatives of distant active regions) and the radio fluctuations preceding a solar flare. The quality of the newly installed 16-channel spectropolarimeter allows for the conclusion that the RT-32 can successfully be employed to carry out specific tasks when studying the fine structure of solar atmosphere and coronal magnetic fields.

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SAULES MIKROVIĻŅU NOVĒROŠANAS PERSPEKTĪVAS VENTSPILS RADIOASTRONOMIJAS CENTRĀ

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K o p s a v i l k u m s

Rakstā apskatītas Saules novērošanas perspektīvas, tehniskās īpašības un unikālas iespējas ar Ventspils starptautiskā radio astronomijas centra raditeleskopu RT-32.

Radioteleskopa RT-32 aprīkošana ar spektropolarimetru pārveido to par unikālu instrumentu pasaules līmenī, ar ko var iegūt Saules mikroviļņu starojuma divdimensionālus attēlu komplektus dažādiem viļņa garumiem. Radioteleskopa ģeogrāfiskais stāvoklis nodrošina Saules novērojumus laikā, kad tas nav iespējams ar analoģiskiem instrumentiem. Ar RT-32 Saules mikroviļņu attēlu arhīvs nozīmīgi papildina esošas novērojumus.

Tiek piedāvāts un analizēts iespējamais uzdevumu saraksts Saules fizikā, pamatots uz plānotiem RT-32 novērojumiem.

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