NEW DECAMETER RADIOPOLARIMETER URAN-2

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The description of the new decameter radiopolarimeter is submitted. It is created based on the phased array URAN-2, which is the greatest decameter array in the world after UTR-2, having the effective area about 30 000 m^2, consisting of 512 broadband dipoles and working at frequencies from 10 up to 30 MHz. Polarimeter works at the central frequency of 24.75 MHz in a band of 10 kHz and 0.3 kHz. It provides reception of circular polarization waves by the horizontal crossed dipoles from any direction. Its sensitivity is ≈100 Jy. With the URAN-2 radiopolarimeter polarizing characteristics of a sporadic radio emission of the Sun (bursts of II and III types), and Jupiter (L- and S-bursts) are investigated. The obtained data will consist well with the results derived in adjacent frequency ranges. At research of the radio emission of Cyg A and Cas A the essential fluctuations of a degree of circular polarization (Stokes V parameter) of these sources radiations are found. This is caused, presumably, by ionosphere inhomogeneity. It is unique radiopolarimeter really working on so low frequencies. The URAN-2 radiopolarimeter organically supplements unique Ukrainian system of URAN decameter radio telescopes.

INTRODUCTION

It is attached great importance to definition of polarizing characteristics of radiation in radio astronomy. It is known that they are one of the basic criteria of generation mechanisms of radiation and influence of the environment upon propagation path.

In adjacent frequency ranges several radiopolarimeters work, some of them: Nancy, Potsdam, IZMIRAN and on higher frequencies: Nobejama, RATAN, and others.

In Ukraine the unique system of URAN decametric radio telescopes is functions, but except for short time (1983–1989, URAN-1) the polarizing measurements using this one were not carried out. For increasing of self-descriptiveness URAN system it is expedient to add its measuring complex, allowing investigating the polarizing characteristics of a radio emission of various space sources in the most low-frequency range accessible to registration at the surface of the Earth – decametric.

EQUIPMENT AND OBSERVATIONS

With this purpose based on the antenna of URAN-2 radio telescope (coordinate: 49°37′49′′N; 34°49′34′′E; total area: 28 000 m^2 – the equivalent of a round dish of 190 meter diameter; frequencies: 9–30 MHz; beam size: $3.5^\circ \times 7^\circ$ (at 25 MHz); polarization: two linear or two circular), being now by the second tool in the world after UTR-2 on sensitivity and, accordingly, by the world's largest decametric tool with an possibility of polarizing definitions, radiopolarimeter has been created. The general view of URAN-2 antenna is shown in Fig. 1.

In Fig. 2 the functional scheme of the radiopolarimeter is submitted. In each of blocks of the circuit its basic characteristics are shown. Their some design performances are shown in Fig. 3. For big array consisting of horizontal cross-dipoles, definition of polarizing characteristics of radiation from the directions which are

Figure 1. The general view of URAN-2 antenna

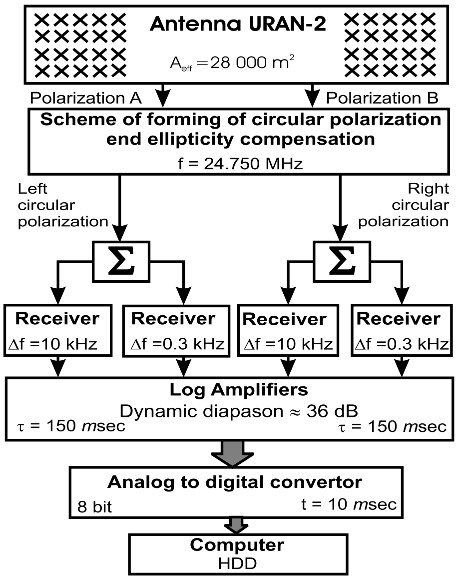
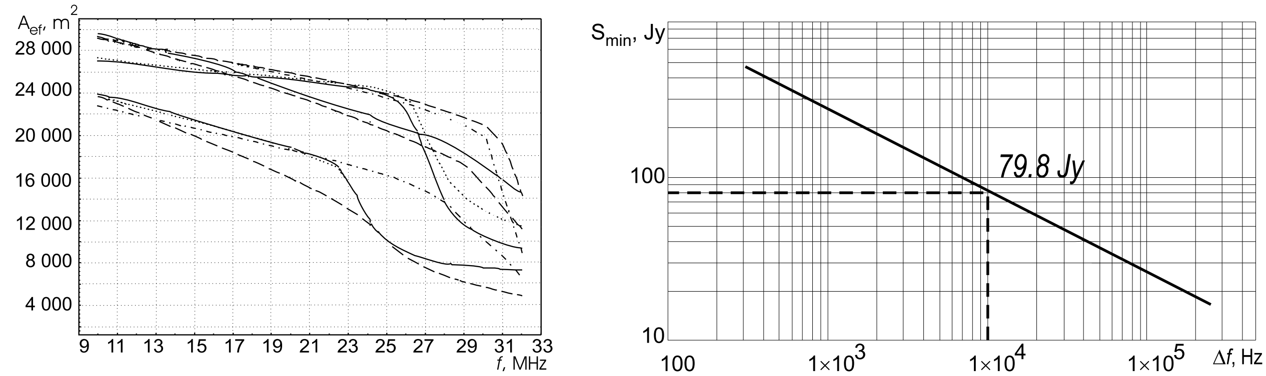


Figure 2. The functional scheme of URAN-2 radiopolarimeter

distinct from zenith are problematic. The method of distortions elimination of the circular-polarized radiation derived by horizontal cross-dipoles from directions with various zenith corners is stated [1, 2]. It is approved during mentioned observations with URAN-1 radiopolarimeter.

The major task which was put at creation URAN-2 radiopolarimeter is: the studying of polarizing characteristics of a sporadic radio emission of the Sun and Jupiter. Measurements have shown that the values of a degree of circular polarization for radiation of the basic tone (IIIF) are 20–30%; for the second harmonic (IIIH) – 5–10%, for the bursts IIIb – 40–50%. It consist well with the known data. Prominent feature of some bursts drifting pairs (DP) is that the greatest degree of polarization is not observed in a maximum of intensity of the drifting pair elements, but at the regions increasing and decreasing of bursts intensity (on fronts). In Fig. 4 an example of record of solar noise storms of type DP burst is shown. In the top window of record received with URAN-2 radiopolarimeter the change of intensity of the right and left-hand not calibrated signals in relative units (scale ADC), and in bottom – the change of a degree of circular polarization in percentage is shown.



a) b)

Figure 3. The design performances of URAN-2 radiopolarimeter: dependence of the effective area on the frequencies for some directions (a); sensitivity of radiopolarimeter to the pass band of receivers (b)

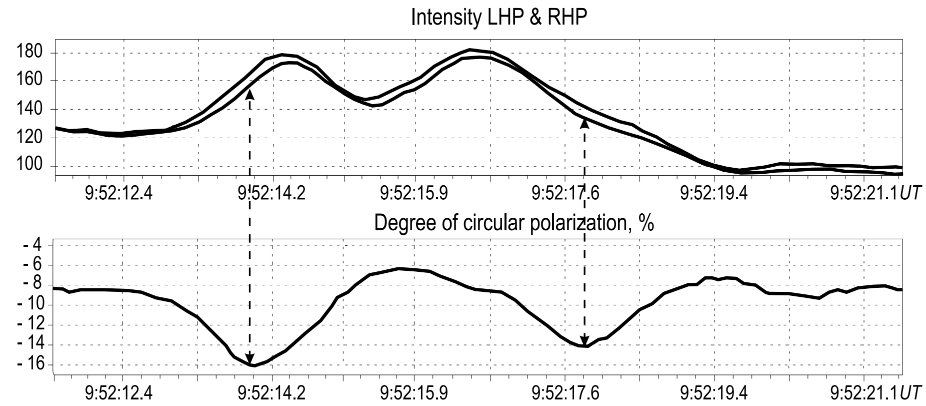
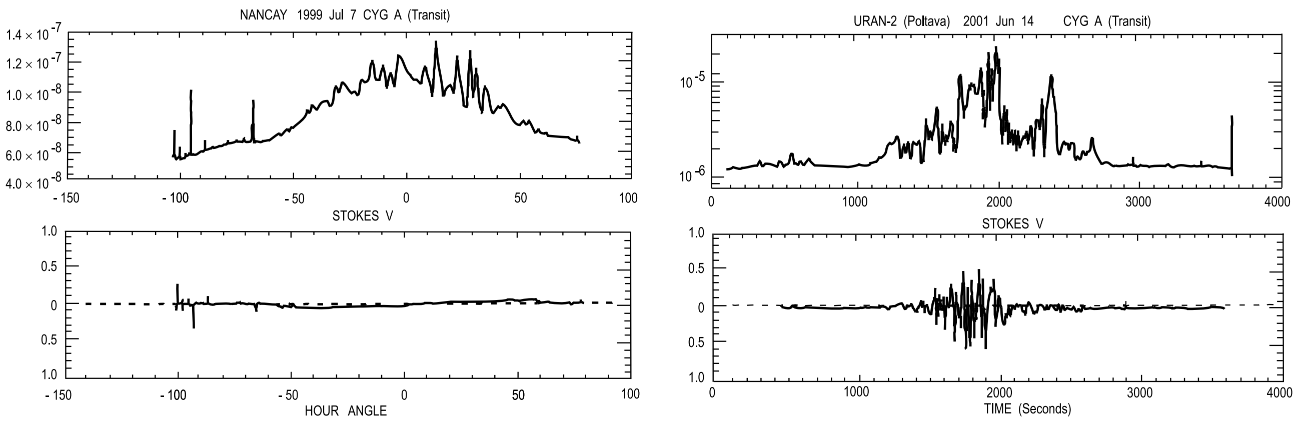
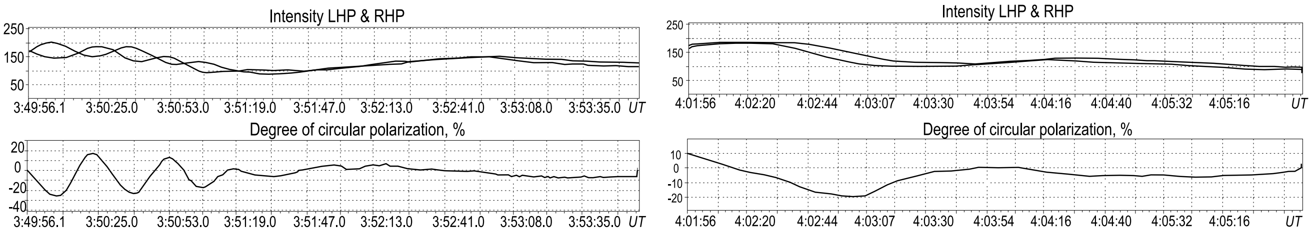


Figure 4. The fragments of record of solar noise storm of type drifting pairs (DP) burst on July 14, 2001



a) b)

Figure 5. The measurements of the Stokes V during the observations of the Cyg A calibration source: in Nancay (a); using URAN-2 (b)



a) b)

Figure 6. Fluctuations of a circular polarization degree of radiation from Cas A on June 11, 2003: fast fluctuations $\approx$30 s (a); slow fluctuations $\approx$1.5 min (b)

The observations with URAN-2 and receiver PRP (India) of the Jupiter sporadic radio emission have shown that the degree of circular polarization of L-bursts is 50–80%, of S-bursts – 0–10%.

During the observations of Cyg A derived by URAN-2 with DSP (France – Austria) unexpected fluctuations of a circular polarization degree, not observed during the similar observations in Nancy, have been found out (see Fig. 5).

We had been carried out the observations of Cyg A and Cas A with URAN-2 radiopolarimeter to explain this effect. In total, Cas A was observed during 69 hours, and Cyg A – 87 hours. Observations were basically made in summer, at night, near to the culmination of the sources. In Fig. 6 characteristic fragments of record of these observations are shown. Essential fluctuations of a circular polarization degree with the various periods are visible.

DISCUSSION AND CONCLUSION

Fluctuations of the flow of a space sources radio emission as a result of influence of an ionosphere are well-known.

It appears from this that the essential fluctuations of a circular polarization degree are also observed. A probable explanation of this effect is the various size of absorption of ordinary and extraordinary waves in ionospheric inhomogeneity. The observable average degree of Cas A and Cyg A circular polarization is also changed from session to session. But, in general, its fluctuations did not exceed several percentages. The value of an average of dot polarization degree of for URAN-2 radiopolarimeter sources which is distinct from zero, also is possible to explain the various conditions of distribution in ionosphere of ordinary and extraordinary radiation components, and its changes from session to session depend on a condition of an ionosphere [3].

Thus, rather short time of operation URAN-2 radiopolarimeter allows us to make the following conclusions:

- opportunity of adaptation URAN-2 radiopolarimeter for a wide range of applications;
- Faraday rotation in ionosphere does not render essential influence on value of a circular polarization degree of a space radio emission at frequency of 24.75 MHz using the expansion of receivers pass band up to 10 kHz;
- fluctuations of a circular polarization degree of radiation from discrete radio sources, caused, apparently, by conditions in ionosphere are found out;
- necessity of the further upgrading URAN-2 radiopolarimeter.

We consider that the perspectives of polarizing observations with URAN-2 radio telescope are rather attractive and demand the radiopolarimeter development which should go on a way of multifrequency measurements or expansion of a bandwidth of a received signal.

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[1] *Abranin E., Bazeljan L., Brazhenko A.* The controlled aerial of circular polarization 2. Choice of the optimum cheme // Izvestiya VUZ: Radiofizika.–1987.–**30**, N 5.–P. 619–623.

[2] *Bazeljan L.* The controlled aerial of circular polarization. 1. Settlement relation // Izvestiya VUZ: Radiofizika.–1987.–**30**, N 4.–P. 516–521.

[3] *Zhelezniakov V. V.* Radio emission of the Sun and planets.–Pergamon Press, 1969.–697 p.