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ASTRONOMY

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Fig. 1

Figure 1: Fig. 1

Abstract**Full Text****ASTRONOMY****V. Ya. GOL' NEV, N. M. LIPOVKA, Yu. N. PARIISKII****OBSERVATIONS OF THE RADIO EMISSION OF JUPITER AT A WAVELENGTH OF 6.5 cm AT PULKOVO***(Presented by Academician V. A. Kotel'nikov, 14 III 1964)*

1. In October–November 1963, at the Main Astronomical Observatory of the USSR Academy of Sciences, observations of the radio emission of Jupiter were carried out with the large Pulkovo radio telescope at a wavelength of 6.5 cm. A broadband direct-amplification receiver with a parametric amplifier at the input was used as the radiometer. The sensitivity of the radiometer was 0.05 K with a time constant of 3 sec. All observations were carried out on the meridian in the transit mode. Polarization with a position angle of 45° was recorded. Forty-one transit curves of Jupiter were obtained. A sample record (12 XI 1963, $\lambda = 6.5$ cm) is shown in Fig. 1a, and the averaged transit curve in Fig. 1b. After correction for the smoothing effect of the time constant (1), the curve shown in Fig. 1c was obtained.

Fig. 1

2. Taking the flux from the radio source 3C 273 to be $27.4 \cdot 10^{-26}$ W/m² Hz at a wavelength of 6.5 cm, we find that the flux from Jupiter is $8.15 \pm 0.8 \cdot 10^{-26}$ W/m² Hz (at a distance of 4 AU). This corresponds to a brightness temperature of the disk equal to $324 \pm 30^\circ$ K. Thus, the excess over the disk temperature obtained from infrared observations (128° K) is 196° K.

Figure 2 shows the dependence of the integral flux of the radio emission and of the brightness temperature of Jupiter's disk on wavelength⁽³⁾; observations of the GAO are marked by circles. The values of the flux and the equivalent disk temperature agree well with the general variation of these quantities with wavelength. We note that the present measurements agree better with the upper group of points in the centimeter range. Analysis of observations at Pulkovo at a wavelength of 3.0 cm⁽⁴⁾ also gives an equivalent disk temperature of about $185^\circ \pm 20^\circ$ K, i.e., 57° higher than the "infrared" temperature; therefore we believe

that the dashed curve in Fig. 2b is closer to the real course of the temperature with wavelength.

3. The estimate of the dimensions of the radio-emitting region at a wavelength of 6.5 cm was made by the method described in ⁽⁵⁾. The size of the antenna beam, at the half-power points, was determined from the sources 3C 48, 3C 268, and 3C 273. The last source was observed at the same altitude above the horizon as Jupiter; therefore errors in interpolating the size of the BPR beam with altitude are absent. The size of the source 3C 273 was taken into account according to the data...

its occultation by the Moon ⁽⁶⁾. The theoretical extrapolation of the half-power beamwidth from the sources 3C 48 and 3C 286 to the elevation of 3C 273 agrees to within 0'.03 with the observations of 3C 273 (2'.5 and 2'.18, respectively); excellent agreement was also obtained for the dimensions at the zero-power points (2'.3 and 2'.35 from the beam axis).

Fig. 2

The results of the observations at a wavelength of 6.5 cm were compared with the calculated values of the beam broadening for various models of the radio-emitting region. The different models correspond to different values of the Gaussian parameter σ_{eqv} —the parameter of a certain equivalent Gaussian source that gives the same beam broadening $\Delta\varphi_A$ as the given model of the radio-brightness distribution.

The equivalent values σ_{eqv} and the expected beam broadenings $\Delta\varphi_A$ at the half-power points were calculated for the following models:

- 1) A uniformly bright disk with a diameter equal to the ephemeris value of the optically visible disk.
- 2) Two point sources on Jupiter's limb (one in the east, the other in the west) plus a uniformly bright optical disk. The total flux of the point sources corresponds to the excess flux at a wavelength of 6.5 cm over the radiation of an absolutely black body with temperature 128° K.
- 3) A Gaussian source of size $3D$ plus a uniformly bright disk.
- 4) Two Gaussian sources at a distance $3D$ plus a uniformly bright disk.

The last two models were constructed on the basis of decimeter observations ⁽⁶⁻⁸⁾; the radiation of the planet's disk in these models also corresponded to a temperature of 128° K. The observations (see Fig. 3) show that the beam broadening is significantly smaller than according to models 3 and 4, but definitely larger than according to model 1, and slightly larger than according to model 2. The radio emission is practically absent at a distance of $1.5R$ from the center of Jupiter.

The results of angular measurements of the radio-emitting region responsible for the enhanced radiation of Jupiter are presented in Fig. 4. It is easy to see

Fig. 3

Figure 2: Fig. 3

Fig. 4

Figure 3: Fig. 4

that in the range 75–21 cm the size of the region of enhanced radiation is equal to $3D$ and practically does not change; at a wavelength of 6.5 cm it is about $(1.3 \pm 0.2)D$; at a wavelength of 3.02 cm ⁽⁴⁾ the region of enhanced radiation practically coincides with the visible disk of the planet.

At present it may be regarded as firmly established that in the decimeter range the enhanced radiation comes from radiation belts existing around the planet. Thus, measurements of the dimensions of Jupiter

indicate a displacement of the maximum radio emission of the belts toward the surface of the planet with increasing frequency, i.e., the emission spectrum (and consequently also the energy spectrum of the electron component of cosmic rays in the belts) is flatter in the inner parts of the radiation belts. As is known, the same phenomenon is also observed in the terrestrial radiation belts.

Fig. 3

In principle, knowledge of the distribution of the radio brightness of Jupiter's enhanced emission at different wavelengths would make it possible to obtain important information on the distribution of the density of the electron component of cosmic rays with height above the planet's surface. However, the observational data are still too scanty, and quantitative estimates cannot be made. Measurements with substantially higher resolving power are needed.

Fig. 4

4. The upper limit of the amplitude of the variation with longitude (systems II and III) of Jupiter's flux observed at a wavelength of 6.5 cm is about 2%. This makes it possible to estimate the upper limit of the polarization of the radio emission of the radiation belts at a wavelength of 6.5 cm, since, owing to the noncoincidence of Jupiter's magnetic axis with the rotation axis, the power received in a fixed plane of polarization will vary. We found that the percentage polarization of the "excess" emission (i.e., after allowing for blackbody emission with $T = 128^\circ \text{ K}$) at a wavelength of 6.5 cm is less than 18%. In making these estimates we assumed that the position of Jupiter's magnetic pole is $L_{\text{III}} = 195^\circ$, $B = 80^\circ$.

5. Attempts to establish a correlation between variations in the radio-emission flux of Jupiter recorded at a wavelength of 6.5 cm and solar activity have not yet led to definite results. Apparently, the fluctuations of the recorded antenna temperature of Jupiter are mainly connected with the finite sensitivity of the

radiometer.

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CITED LITERATURE

1. Yu. N. Pariiskii, *Astr. Zh.*, **38**, No. 5, 24 (1961).
2. *Sci. News Letters*, **82**, No. 20, 317 (1962).
3. J. A. Roberts, *Planetary and Space Sci.*, **11**, No. 3, 221 (1963).
4. D. V. Korolkov, Yu. N. Pariiskii, and G. M. Timofeeva, *DAN*, **157**, No. 4 (1963).
5. D. V. Korolkov, Yu. N. Pariiskii, G. M. Timofeeva, and S. E. Khaikin, *DAN*, **149**, No. 1, 65 (1963).
6. F. J. Kerr, *Sky and Tel.*, **24**, 254 (1962).
7. V. Radhakrishnan and J. A. Roberts, *Phys. Rev. Letters*, **4**, 493 (1960).
8. D. Morris and G. L. Berge, *Aph. J.*, **136**, 276 (1962).
9. M. S. Roberts, *Astron. J.*, **67**, 280 (1962).

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