Astronomy

A. D. Kuzmin, B. J. Clark

1965

SovietRxiv

Abstract

Full Text

Astronomy

A. D. Kuzmin, B. J. Clark

Measurements of the Polarization and Distribution of the Brightness Temperature of Venus at a Wavelength of 10.6 cm

(Presented by Academician V. A. Kotelnikov on 31 XII 1964)

1. One of the fundamental questions in the physics of Venus, the solution of which determines the choice between models with "cold" and "hot" atmospheres and, consequently, the temperature of the planet's surface, is the question of the nature of the layer responsible for the radio emission in the wavelength range from 3 to 20 cm. The decisive experiment for choosing one of these models and eliminating the indicated ambiguity may be the detection of differential polarization of the radiation from different parts of the visible disk of the planet. The high resolution necessary for carrying out such measurements of Venus was achieved with the interferometer of the Owens Valley Radio Astronomy Station of the California Institute of Technology, on which, in 1962, trial measurements were made of the distribution of radio brightness over the disk of Venus in unpolarized radiation (^1). Around the inferior conjunction of 1964 these studies were continued by us according to a considerably broader program, including polarization measurements.

2. The measurements were made in May–July 1964 at a wavelength of 10.6 cm, with baselines from 600 to 6500 λ and with various polarizations.

The visibility function and its dependence on the polarization of the received radiation and on the orientation of the effective baseline of the interferometer relative to Venus were measured, as well as the intensity and polarization of the planet's integral radio emission.

3. The results of measuring the differential polarization, presented in Fig. 1 as the difference of the visibility functions for polarizations perpendicular $F_\perp$ and parallel $F_\parallel$ to the effective baseline of the interferometer as a function of the resolving power in the interferometer, show a difference between $F_\perp$ and $F_\parallel$ substantially exceeding the measurement errors, and definitely establish the fact that differential polarization is present in the radio emission of Venus. Consequently, the greater part of the radio emission of Venus in the 10-centimeter wavelength range is caused by a continuous medium. This medium is apparently the surface of the planet.

Fig. 1

Figure 1: Fig. 1

4. The magnitude of the differential polarization, and consequently also the difference $F_{\perp} - F_{\|}$, depends on the dielectric constant ε of the emitting medium. This dependence, calculated for a smooth sphere and also shown in Fig. 1, makes it possible to determine from the measurement results the value of ε.

The best agreement of the experimental data with the calculation, determined by the least-squares method, corresponds to

$$\varepsilon = 2.2 \pm 0.2.$$

Taking into account the influence of surface roughness, carried out using data from radar measurements at the nearby wavelength of 12.5 cm (^2), increases the obtained value of the dielectric constant of the surface of Venus to $\varepsilon = 2.5$.

5. Analysis of the measurement results for the dependence of the visibility functions on the orientation of the interferometer baseline and on the hour angle, as well as of the polarization of the planet' s integrated radio emission, revealed an asymmetry in the distribution of brightness temperature over the disk of the planet*. In one direction the brightness temperature at the edge of the disk is 25-30% lower than in the orthogonal direction.
6. Assuming that the regions of reduced brightness temperature are the polar regions of the planet, the orientation of the pole of Venus was determined.

Fig. 1

From the polarization measurements, the coordinates of the pole of Venus in the ecliptic coordinate system are

$$\lambda = 213^{\circ}, \qquad \beta = 64^{\circ},$$

which corresponds to the equatorial coordinates

$$\alpha = 15^{h} 50^{m}, \qquad \delta = 47^{\circ}.$$

From measurements of the dependence of the visibility function on the hour angle,

$$\lambda = 192^{\circ}, \qquad \beta = 74^{\circ},$$

which corresponds to

$$\alpha = 15^h 50^m, \qquad \delta = 59^\circ.$$

7. Analysis of the magnitude of the first maximum and of the position of the zero of the visibility function also made it possible to estimate the distribution of brightness temperature in the equatorial direction and the diameter of the radio-emitting region. In the equatorial direction there is a tendency toward a slight increase in brightness temperature near the terminator relative to the antisolar point. The diameter of the region responsible for the radio emission of Venus in the 10-centimeter wavelength range is $0.7 \pm 0.9\%$ smaller than the ephemeris diameter and is

$$d = 12\,114 \pm 110 \text{ km}.$$

8. The brightness temperature of Venus, averaged over the apparent disk of the planet and measured on 30 V–1 VI and 17 VII 1964, is 582 and 576°K. Taking into account the value determined above, $\varepsilon = 2.2$, and the characteristics of the radio-brightness distribution, this corresponds to a true temperature of the planet' s surface at the antisolar point of

$$630 \pm 70^\circ\text{K}.$$

9. The observed "darkening" of the poles may be interpreted as:

a) A latitudinal decrease in the true surface temperature. In this case the surface temperature in the polar regions is $\sim 450^\circ$K.

* The polarization of the integrated radio emission of a planet with an asymmetric brightness-temperature distribution was predicted by V. S. Troitskii (3).

b) The presence in the near-polar regions of Venus of a surface colder than the absorbing atmosphere (ionosphere), with an optical thickness of ~ 0.4.

A more detailed article on the results of the work will be published in the *Astronomical Journal*.

The authors express their deep gratitude to the director of the Owens Valley Radio Observatory, Professor G. Stanley, for his full assistance in carrying out the present work.

Physical Institute named after P. N. Lebedev
Academy of Sciences of the USSR

Owens Valley Radio Astronomy
Observatory of the California Institute
of Technology, USA

Received
24 XII 1964

References Cited

[1] B. G. Clark, C. L. Spencer, *Astron. J.*, **69**, 59 (1964). [2] R. L. Carpenter, *Astron. J.*, **69**, 2 (1964). [3] V. S. Troitskii, *Astron. zhurn.*, **31**, 511 (1954).

Note: Figure translations are in progress. See original paper for figures.