A. P. MOLCHANOV

1964

SovietRxiv

Abstract

Full Text

A. P. MOLCHANOV

DETERMINATION OF THE POSITION OF THE REGION OF RAPID CHANGE IN THE CHARACTERISTICS OF THE SOLAR ATMOSPHERE FROM RADIO-ASTRONOMICAL OBSERVATIONS

(Presented by Academician V. A. Kotel' nikov, 27 V 1964)

Radio-astronomical observations of solar eclipses make it possible to determine the radio radius of the Sun r_p (relative to the radius of the photosphere $r_\odot$) from the difference between the times of contact of the lunar and solar disks, measured by radio methods and optically. In doing so, observations are made of the II and III contacts, near which the change in the occulted area of the solar disk occurs considerably more rapidly, and the accuracy of determining $r_\odot$ is appreciably higher than in the case of using the I and IV contacts.

Observations of solar eclipses have been carried out repeatedly, and the results of some of them have proved suitable for finding r_p by the method indicated above. In this connection, it is important to select those cases in which there were no local sources of radiation on the limb of the solar disk. This condition was satisfied by the following observations, carried out when the activity of the Sun was low.

In 1954, at $\lambda 0.86$ cm, it was found that $r_p/r_\odot = 1.0085 \pm 0.0025$ ([1]) and $r_p/r_\odot = 1.0068 \pm 0.0005$ ([2]). For $\lambda 3.2$ cm ([3]), additional processing of the observational results gave $r_p/r_\odot = 1.030 \pm 0.004$. For $\lambda 10$ and 50 cm, the value of the radio diameter was determined from published curves of the change in the flux of solar radio emission during the same eclipse ([4,5]), according to which $r_p/r_\odot = 1.035 \pm 0.008$ and $r_p/r_\odot = 1.06 \pm 0.01$, respectively.

For the 3.2 cm wave, moreover, the results of observations in different years are known, during which the activity of the Sun was likewise low. Use of these observations gives results close to those cited above: $r_p/r_\odot = 1.030 \pm 0.003$ (1951 ([6])), $r_p/r_\odot = 1.029$ (1952 ([7])), $r_p/r_\odot = 1.033 \pm 0.003$ and $r_p/r_\odot = 1.034 \pm 0.003$ (1962 ([8])). Measurements at a wavelength of 4.5 cm in 1962 ([9]) also gave close values: $r_p/r_\odot = 1.034 \pm 0.005$ and $r_p/r_\odot = 1.032 \pm 0.005$.

In 1963, observations of an eclipse were carried out at wavelengths of 2; 3.2; 4.5 and 10 cm. Preliminary processing of the results of measurements of the times of the II and III contacts led to the conclusion that at all the wavelengths used

Fig. 1

Figure 1: Fig. 1

the radio radius remained approximately the same: $r_p/r_\odot = 1.030 \pm 0.005$ at $\lambda 2$ cm; $r_p/r_\odot = 1.031 \pm 0.003$ and 1.024 ± 0.005 at $\lambda 3.2$ cm (on the two sides of the disk); $r_p/r_\odot = 1.033 \pm 0.004$ and 1.026 ± 0.003 at $\lambda 4.5$ cm; $r_p/r_\odot = 1.028 \pm 0.008$ at $\lambda 10$ cm.

The results of the observations are plotted in Fig. 1. It follows from them that, undoubtedly, there exists a region of such values of r_p for which the growth of the radio radius of the Sun with increasing wavelength sharply slows down; in other words, there is a characteristic value of the radio radius of the Sun that, within certain limits, depends little on wavelength.

The reliability of the values found for r_p is determined by the following factors:

1. The observational results used for the calculations (13 cases) were obtained independently on 12 radio telescopes. Since 12 values of r_p

belong to that part of the curve for which $r_p \simeq$ const, then the existence of a characteristic value of the Sun' s radio radius may be considered very probable.

2. Fluctuations in the records of the radio-emission flux constituted the main part of the error in determining the moments of the radio contacts. The values of these errors were given above and corresponded to a region of such a shift of the lunar and solar disks in which the values of r_p proved to be averaged over an arc of circumference within a central-angle zone which, in different cases, ranged from 30 to 70°.

3. The possibility that a bright "limb" on the solar disk might influence the results of the determinations of r_p was checked by analyzing the curves of the flux records. No such influence was noticed in the records used.

Fig. 1. Results of observations carried out simultaneously in 1964 are shown by solid lines; observations at 3.2 and 4.5 cm from different years (with low solar activity) by dashed lines; preliminary results of observations in 1963 by hatching.

The character of the dependence obtained, $r_p(\lambda)$, corresponds to the modern conception of the structure of the lower layers of the solar atmosphere. It is assumed here that the latter consist of separate independent dense elements, cold and hot, and, at a somewhat greater height, of colder and denser fibers and of hotter and less dense matter between them ([10,11]). The dense and cold fibers are considerably less transparent to radio waves than the matter between them, and the region of the Sun' s atmosphere containing them determines the value of the radio radius.

With increasing λ, the radio radius continues to remain unchanged until the absorption between the fibers (and above their boundary) increases so much that the matter becomes only slightly transparent. After this, a further increase in λ will be accompanied by an increase in r_p.

With decreasing λ, as long as the fibers remain opaque, r_p does not change. However, at sufficiently small values of λ, their optical depth becomes small and r_p begins to decrease.

The increase of r_p that begins as λ grows should apparently occur smoothly, without sharp bends, and the determination of the time moments of the II and III contacts may prove difficult. These features are connected with the transition of the Sun' s radio radius into those regions where the properties of the solar atmosphere change comparatively slowly. This may be confirmed by observations of solar eclipses at $\lambda > 20$ cm (for example, observations in 1954 at $\lambda 55$ cm ([5]), $r_p = 1.06 \pm 0.01$), in which the bends on the curve of the variation of the radio-emission flux corresponding to the II and III contacts proved to be less distinct than at $\lambda \leqslant 10$ cm.

With such an interpretation of the results of the determinations of r_p given above, the latter indicate a very great extent of the zone containing the weakly transparent fibers. Analogous considerations, carried out as applied to a "continuous" model of the solar atmosphere, lead to the conclusion that the region with $r_p \simeq$ const corresponds to layers with a rapid increase in electron temperature, causing a sharp increase in the transparency of these layers to radio waves.

It may be expected that determining the Sun' s radio radius for an increased number of wavelength values will make it possible to obtain additional information on the structure of the solar atmosphere. Of particular interest, apparently, is the study of this dependence near the point of sharp bending of the curve $r_p(\lambda)$, i.e., at $0.5 \text{ cm} < \lambda < 3$ cm, since the rate of change of the magni-

values is determined by the structure of the boundary of the region with a sharp change in the characteristics of the solar atmosphere.

Sufficiently accurate determinations of the radio radius of the Sun simultaneously at several wavelengths can be made during observations of solar eclipses.

Leningrad State University
named after A. A. Zhdanov

Received
27 V 1964

CITED LITERATURE

[1] A. E. Salomonovich, Yu. N. Pariiskii, U. V. Khantiltsin, *Astr. zhurn.*, **35**, 659 (1958).
[2] R. I. Coates, I. E. Gibson, I. P. Hagen, *Astrophys. J.*, **128**, 406 (1958).
[3] A. P. Molchanov, E. M. Goncharenko et al., *Trans. V Meeting on Cosmogony, USSR Academy of Sciences*, 1956, p. 197.

[4] C. H. Mayer, B. M. Sloanaker, I. P. Hagen, *Radio Astron. Symp.*, No. 4, Cambridge, 1957, Paper 47.
[5] M. Laffineur, *Radio Astron. Symp.*, No. 4, Cambridge, 1957, Paper 55.
[6] E. I. Blum, I. F. Denisse, I. L. Steiberg, *Ann. d' Astrophys.*, **15**, 184 (1951).
[7] V. S. Troitskii, M. R. Zelinskaya, V. L. Rakhlin, V. G. Bobrik, *Trans. V Meeting on Cosmogony, USSR Academy of Sciences*, 1956, p. 182.
[8] S. S. Veisig, A. P. Molchanov, *Solar Data*, No. 9, 1963.
[9] N. G. Peterova, A. P. Molchanov, V. G. Nagnibeda, *Solar Data*, No. 8, 1963.
[10] V. A. Krat, V. M. Sobolev, *Izv. GAO*, No. 160 (1958).
[11] K. de Jager, *Structure and Dynamics of the Solar Atmosphere*, IL, 1962.

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