OBSERVATIONS OF RADIO SPOTS AT 4000 Mc/s.

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Summary-

Observations of E-W brightness distribution on the solar disk at 4000 Mc have been carried out with 8-element interferometer with quarter-wavelength plates since June 1954. In this paper the results of observations of the radio spots in 1955 are described. It was observed that the radiation from the radio spot has a small degree of circularly polarized component. The radio spot in the northern hemisphere radiated the excess of r. h. circularly polarized component in the east side of the central meridian, and in most cases the sense of the polarization reversed near the central meridian. The opposite sense was observed in the southern hemisphere. It was confirmed by direct measurement that the sense of polarization varies generally according to the rule found by Piddington and Minnett, i. e. it depends on the position of the radio spot and sunspot cycle. The value of % polarization usually does not exceed 10%.

In dm-cm region, solar radio emission has slowly varying component radiated from the localized radio emissive region (radio spot). The observations of E-W brightness distribution on the solar disk at 4000 Mc have been carried out with 8-element interferometer since June 1954. With the interferometer we can separate S component from the quiet sun radiation, and the radiation from a radio spot from the others. Therefore, we can study S component not statistically but by direct measurement.

In this paper some results of observations in 1955 are described.

Covington[1] and Piddington and Minnett[2] observed that at 10cm there existed a small circularly polarized component. From Covington's data (June-August 1948) Piddington and Minnett found that a sunspot in NE-SW pair of quadrants tends to radiate an excess of left-hand circular polarization and opposite sense for the other pair of quadrants and indicated that this rule relating to the sense of polarization should reverse on this solar cycle. Our observations have confirmed that the sense of polarization varies in general according to this rule.

8-element interferometer with quarter-wavelength plates[3] produces a fan-shaped beam with a half-power width of 4.5′ and main beams are spaced 40′ apart. The observation is carried out every day over a period of about half an hour around the local noon (about 03h U. T.) and about five drift-curves for each of the right-hand and left-hand circularly polarized components of the radiation are obtained.

The drift-curves for r. h. and l. h. circularly polarized component are superimposed and averaged separately. Subtracting the area under the drift-curve for quiet sun from the daily drift-cutves, we obtain drift-curves for radio spots (Fig. 1). It is assumed that the lower envelope of daily drift-curves, superimposed at intervals of about a month, is the drift-curve for quiet sun, as described by W. N. Christiansen.

By time marks made by a clock every one minute, the position of the optical sun with respect to an aerial beam can be found. Therefore, we can find the E-W position of radio spot from the position of peak, and the intensity of the radiation from the radio spot from the area of the peak. In order to find the position and the intensity, the radio spot must be situated away from the other spots, so that the interferometer can resolve it. When two comparably intense radio spots are situated in a nouth-south strip 4.5′ wide, we cannot correctly find the position and the

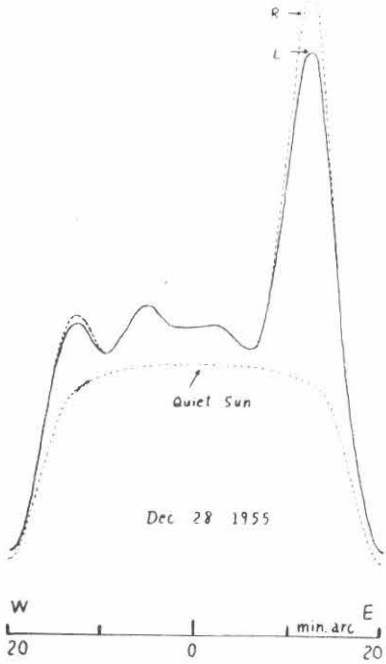


Fig. 1. (a) Drift-curve obtained by the interferometer.

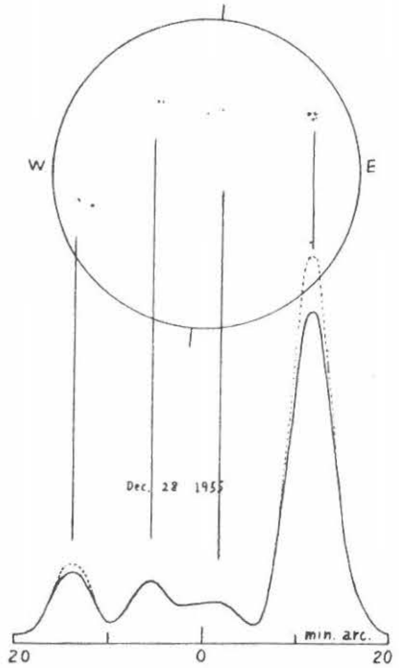


Fig. 1. (b) Drift-curve for the radio spots.

intensity. Recently, as many sunspots appear simultaneously on the disk, there are very few available data. The position of the radio spots generally agree with that of sunspots. The optical data observed at Tokyo Astronomical Observatory were used to see if the radio spot was isolated.

The comparison between E-W distribution of radio spots and the optical data is shown in Fig. 1. The weak radio spots unassociated with sunspots are frequently observed. The intensity of radiation from radio spot varies with the development of the associated sunspot group. But the radio spots do not vanish at the same time as the associated sunspot,

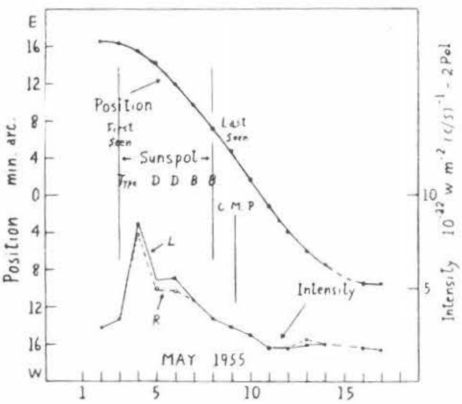


Fig. 2. An example of radio spot observed after the disappearance of the sunspot.

though those become very weak, and those are observed for a fairly long time after the disappearance of the sunspot (Fig. 2).

The intensity of the radiation from the strongest of the radio spots associated with E type sunspot reached to about 40×10^{-22} w. m.$^{-2}$(c/s)$^{-1}$$-2$ polarization, about 25 for C type and about 4 for A type. The flux at 4000 Mc are all converted to the scale at 3750 Mc.

The variation with the solar rotation of the position of the radio spot and of the intensity of the radiation from the radio spot are shown in

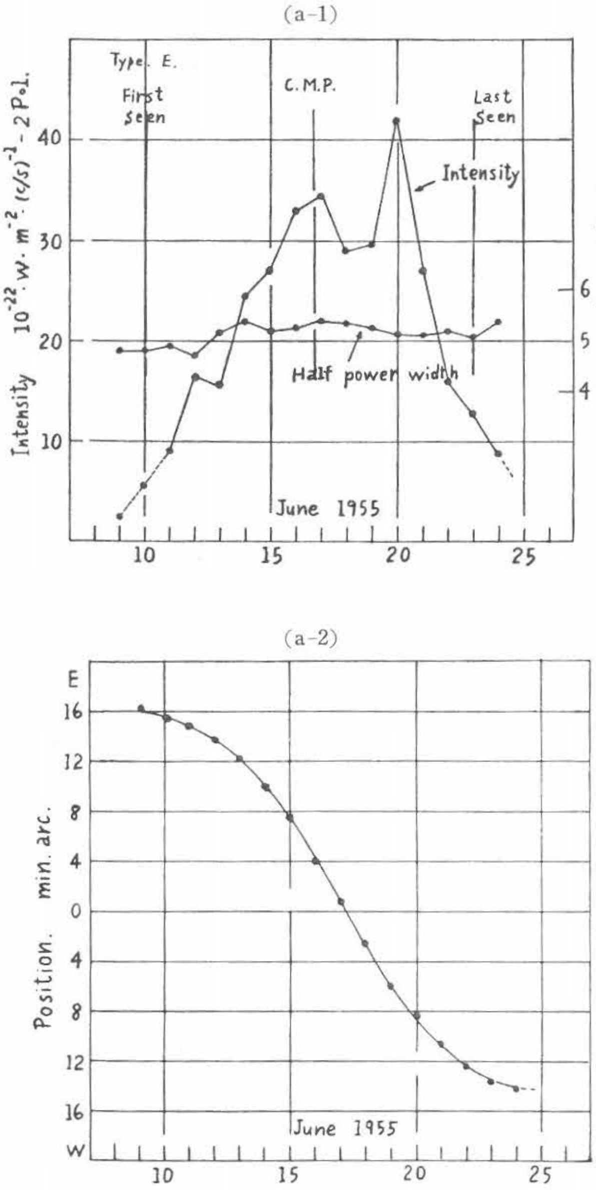
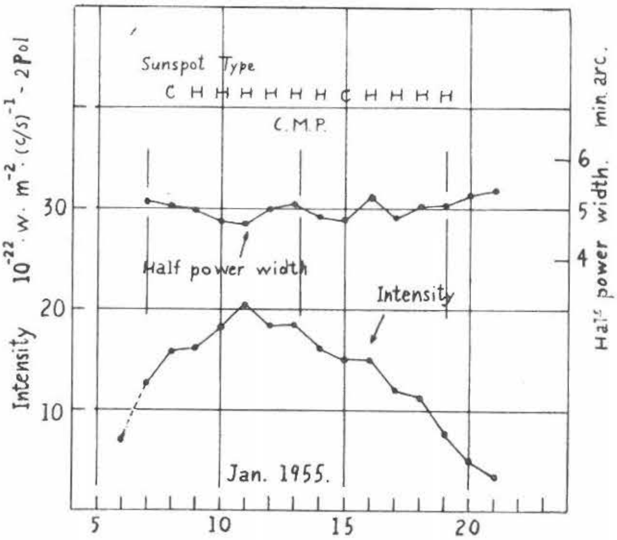


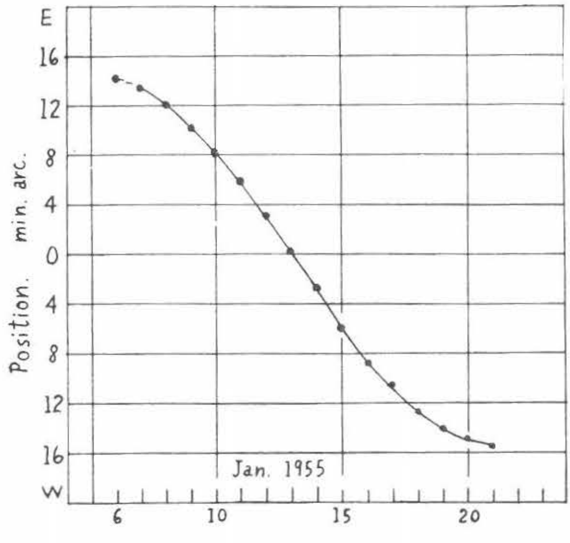
Fig. 3. The position of radio spot and the intensity of the radiation from radio spot.

Fig. 3. The day of C. M. P., appearance and disappearance and the type of sunspot are also shown. Tne variation of position of radio spot agrees with that of sunspot, but at the limb the radio spots are observed one or two days before the sunspot appears or after the disappearance of the sunspot. It shows that the radio spots are situated over the sunspot and have some extent in height. Assuming that the radio spots are point source, and neglecting the effect of refraction, it can be found that the radio spots are situated at the elevation of 0.05 $R_{\odot}$ over the photosphere. Waldmeier[4] derived the model of the coronal condensation above F type sunspot group from the variation of intensity of radiation at 10.7cm with

Fig. 3. (b-1)



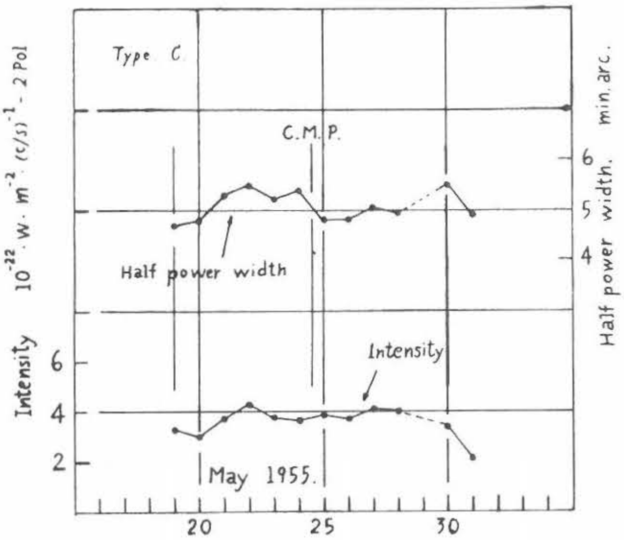
(b-2)



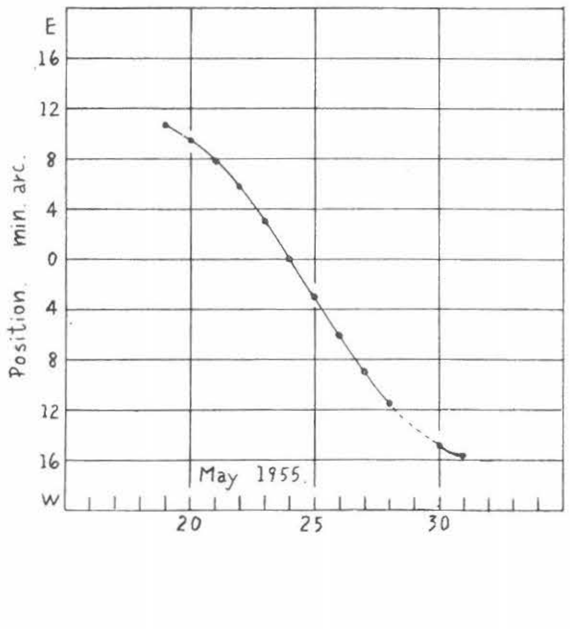
the distance of sunspot group from the center of the disk. It has a semi-ellipsoidal shape with half-axes of 0.153, 0.076, 0.069 solar radii. It will be interpreted with such size and shape that radio spots are observed longer than the sunspots.

The approximate E-W width of the radio spot can be found from the half-power width of the peak as shown in Fig. 1, assuming that the E-W distribution is rectangular. The E-W width of the spot, shown in Fig. 3 (a), was estimated to be about 4′ from the half-power width of the peak 5.2′ on June 20, 1955. This value agrees with that deduced from the results of the eclipse observation[5]. The effective temperature is 0.7 ×

Fig. 3. (c-1)



(c-2)



10^6 °K, as suming square area (16 square min. arc.). Most strong radio spots have E-W width of 3′ to 5′.

As shown in Fig. 3 (a) and (b), the intensity of the radiation decreases with the distance from the center of the disk. In Fig. 3 (a), the intensity decreases to about 20% of the central intensity at the limb, and it seems

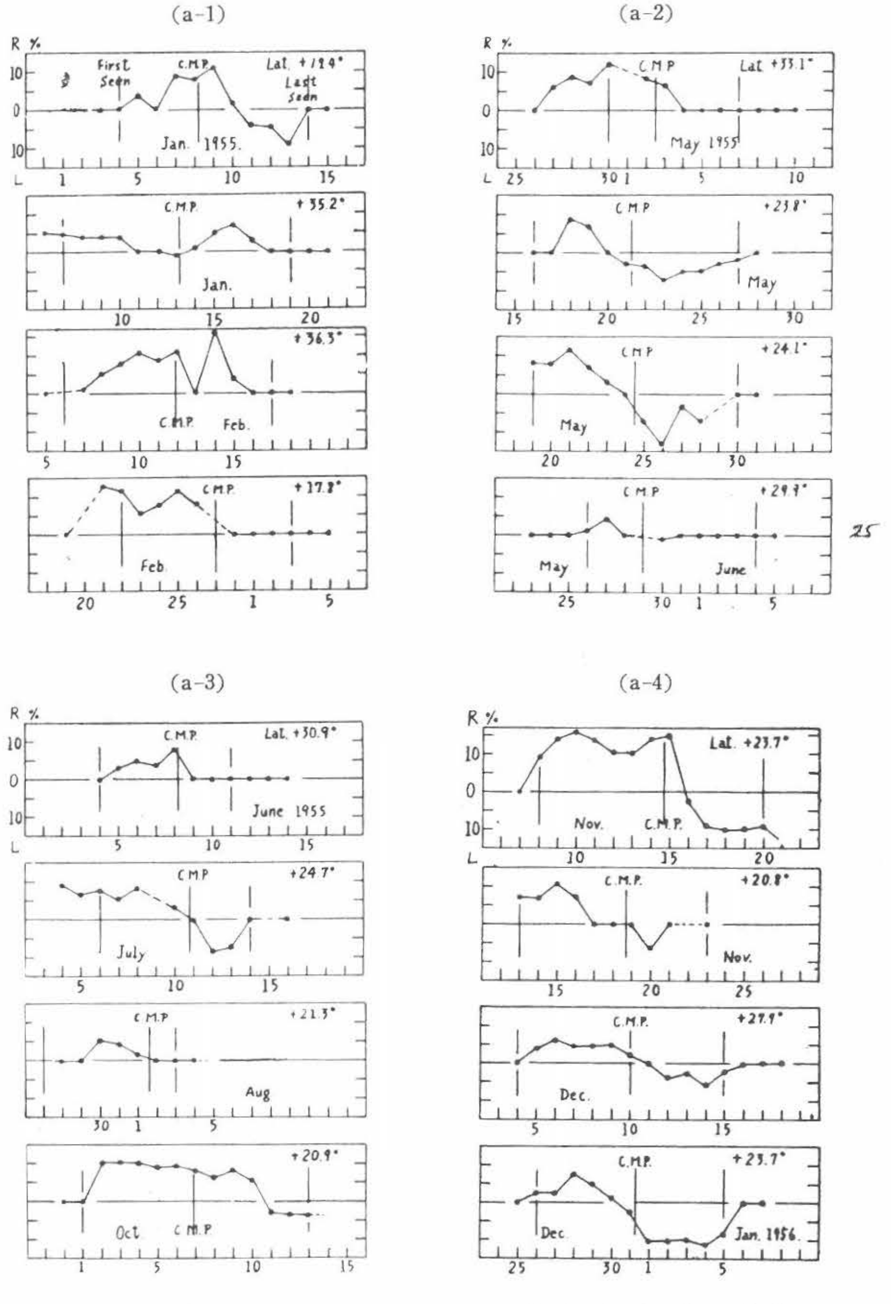
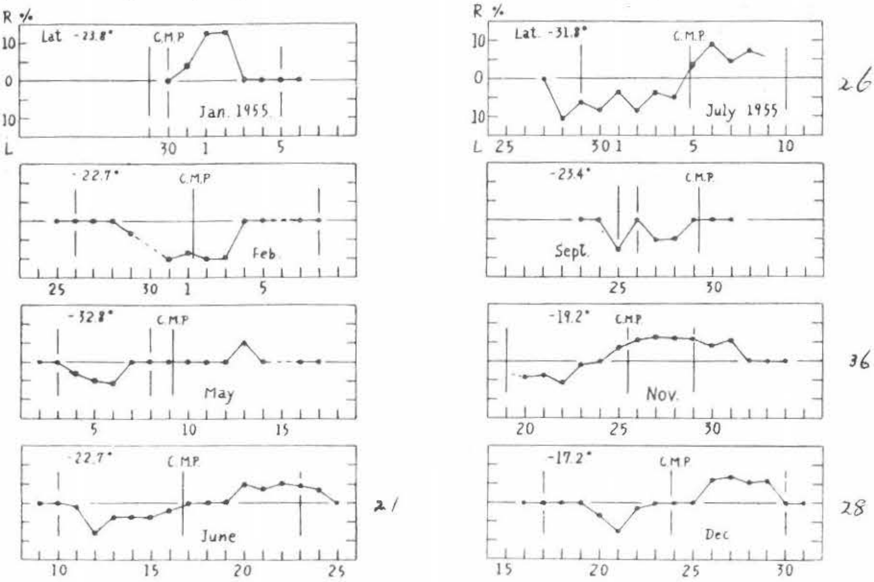


Fig. 4. Variation with the position of % polarization of the radiation from the radio spot.

that the radio spot has a ellipsoidal shape, as descrbed by M. Waldmeier. But, as shown in Fig. 3 (c) and Fig. 2, the intensity of the radiation from the weak spot hardly decreases to the limb. These curves show that the shape of the weak radio spot is approximately spherical and the radio spot extends in transverse direction and becomes flat with its development.

The radiation from the radio spot generally has a small degree of circularly polarized component and the degree of polarization varies from day to day. The results of observations for radio spots which were resolved

Fig. 4. (b-1) (b-2)



by the interferometer are shown in Fig. 4. Data of the sunspot are also shown. The radio-electric convention is adopted. The value of percentage polarization was calculated from the peak value of drift-curve for radio spot which is proportional to the intensity. The small error will be produced when the shape of the peak for right-hand circularly polarized component is different from that for left-hand. From Fig. 4 it is found that the radio spot in the northern hemisphere radiated the excess of r. h. circularly polarized component in the east side of the central meridian, and in most cases the sense of the polarization reversed around C. M. P.. The opposite sense was observed in the southern hemisphere. These results agree with the rule of the sense of polarization found by Piddington and Minnett, and show that the sense of polarization depends on the position of the radio spot and sunspot cycle. The sense of polarization of the radiation from some weak radio spots did not reverse after C. M. P. and the difference between r. h. and l. h. circularly polarized component vanishd. The radio spot (C. M. P. ; Jan. 13, Lat. + 35.2°), shown in Fig. 4, was the only exception to this rule and the sense of polarization did not reverse. According to the Mt. Wilson magnetic observations in the Pub. A. S. P., the associated sunspot was γ type. The radio spot (C. M. P. ; Feb, 12. Lat. + 36.3°) was also an exception, but after the meridian passage the half-power width of the peak became very large and it seems that the other spot overlapped. Most radio spots, shown in Fig. 4, were associated with β type sunspot. There were few radio spots associated α type sunspot and those were generally weak. The radio spot (C. M. P. ; July 4.9, Lat. $-31.8°$) was associated with α type sunspot and it seems that the sense of polarization reversed, though it was not completely isolated. The value of % polarization usually does not exceed 10 % and the values up to 16 % were observed. The value of % polarization is not proportional to the magnetic field strength of sunspot.

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