RADIO EMISSION OF THE SOLAR POLAR REGIONS AT MILLIMETER WAVELENGTHS

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Regions of enhanced radio brightness in the polar areas of the Sun were detected in 1974 at the Crimean Astrophysical Observatory of the Academy of Sciences of the U.S.S.R. The effective temperatures of these regions exceeded that of the undisturbed Sun by 1500 K and 2200 K at 8.2 and 13.5 mm wavelengths respectively. Radio brightness distributions of the Sun obtained with the 22-m radio telescope, at 8.2 and 13.5 mm with angular resolutions of 1!6 and 2!55 respectively are shown in Figure 1. Regions of enhanced radio brightness near the North Pole of the Sun are seen, beside the typical s-sources at middle and low latitudes.

The consequent investigations of the radio emission of the polar regions with the 22-m radio telescope and of the longitudinal magnetic fields with the Large Solar Telescope of the Crimean observatory showed that: a. the regions of enhanced radio emission are found at latitudes $\phi > 80°$, b. they are identified with local magnetic fields of strengths up to about 100 Gauss (1), c. the effects of enhanced radio emission are characteristic to both poles of the Sun and depend on the orientation of the poles with respect to the line of sight. (2).

A search of the records of previous observations of the Sun at 8.2 and 13.5 mm showed that regions of enhanced brightness have been definitely recorded starting from 1972, after the passing of the maximum of solar activity. On the records of 1968-1972 such regions are not seen.

The polar regions of the Sun were observed in the fall of 1977 at 8.2 and 13.5 mm, with the Crimean 22-m radio telescope, and at 3.5 mm with the 4 m radio telescope of the CSIRO at Epping, Australia (2). The results of these observations are presented in Table 1. The Table shows the angular sizes of the enhanced regions (in the radial direction), their excess effective temperatures over the Quiet Sun's temperature, and also the geolatitude B_o.

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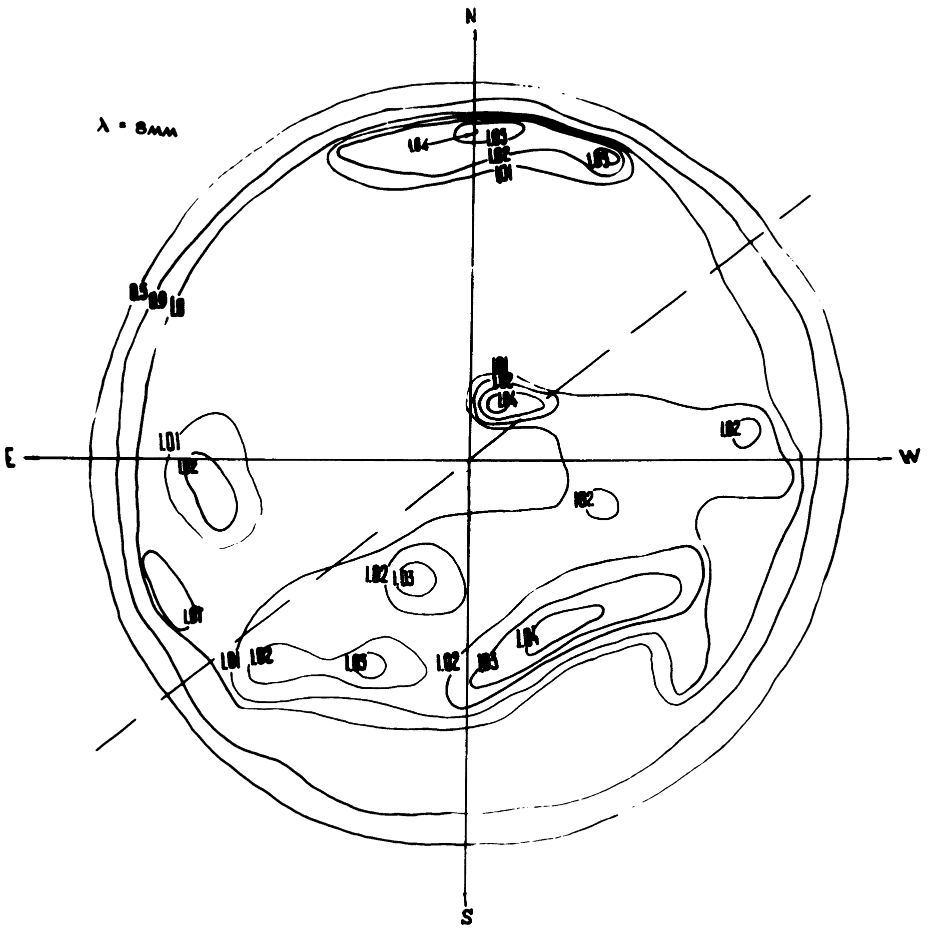

Figure 1a: The distribution of the radio brightness over the Sun 25 September 1974 at 8 mm.

Table 1 shows that the angular size of the regions of enhanced radio brightness is about the same at all wavelengths, and is equal to 1.5-2 arcmin, while the contrast between their temperature and that of the undisturbed Sun at 8.2 and 13.5 mm decreased appreciably from 1974 to 1977.

The variations in the contrast of the temperature of the polar regions with respect to the temperature of the undisturbed Sun may be due to either variations in the temperature of the polar regions themselves with the phase of solar activity, or to variations of the brightness temperature of the Quiet Sun with solar cycle.

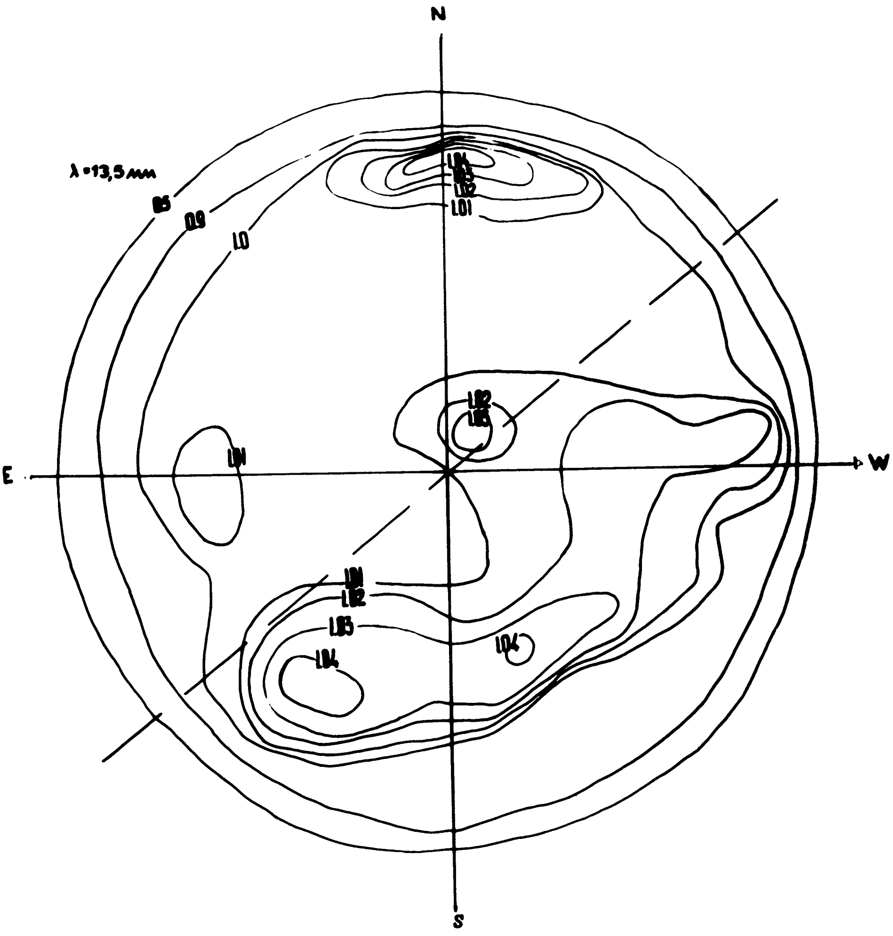

Figure 1b: The distribution of the radio brightness over the Sun 25 September 1974 at 13.5 mm.

TABLE 1

λ	13.5 mm		8.2 mm		3.5 mm
Pole	N	S	N	S	N, S
Θr	1'.7	2'	1'.8	1'.6	1.5
Tr, K	1460	1020	700	530	275
B_o	+5°		+5°		0°
Date of Observations	October 1977				December 1977

T_r = observed temperature increase in polar region as compared with undisturbed Quiet Sun.

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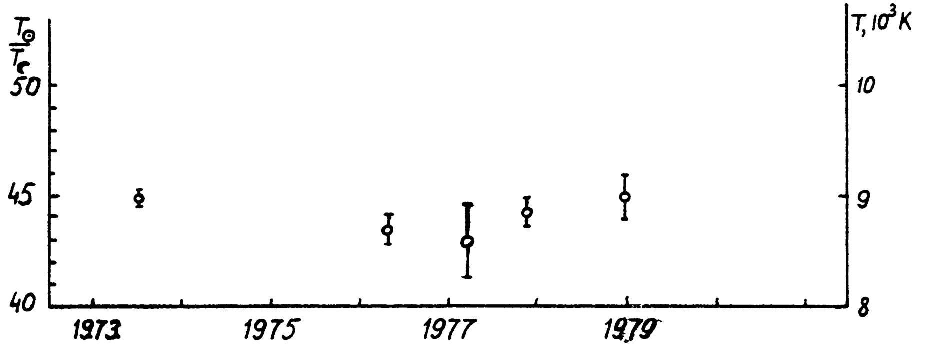

Figure 2: The temperature of the undisturbed Sun at 13.5 mm during the period 1974 to 1979.

For the detection of probable variations of the brightness of the Quiet Sun, the temperature of an undisturbed region on the Sun has been compared with the Moon's temperature at 13.5 mm, using the Crimean 22-m radio telescope.

The temperature ratio of the Moon and the Sun obtained during the period of observations were corrected for the phase of the Moon. The results of the measurements are presented in Figure 2, which shows that during 1973-1977 there was no increase larger than 300 K in the temperature of the undisturbed Sun at 13.5 mm.

Hence the variations of the Sun's temperature cannot account for the decrease of contrast. We conclude that during the period of observations the temperature of polar regions decreased, i.e., the Sun's polar regions are more active at millimeter wavelengths during the minimum of the 11-year cycle of the Sun.

References

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DISCUSSION

Kaufmann: How frequently are observed the excess brightenings at the solar poles?

Stewart: Observed 5 or 6 times per year for several days each time and always see increase.

Kundu: Several years ago, we (Kundu and McCullough) found a region not exactly at the pole, but certainly at very high latitudes. We found that it was associated with many small plage regions scattered all over; and KPNO magnetogram showed also similar magnetic features.

Sheeley: The Sun's polar faculae undergo the same temporal variation that you have described:

1. They are best visible at the time of year that the pole is most visible.
2. They are most abundant during the declining, minimum, and rising phase of the sunspot cycle but are generally absent around sunspot maximum.

Alissandrakis: What is the brightness temperature of the polar source and how does this compare to the brightness temperature of the active regions?

Stewart: Polar source brightness temperatures are of the order of 0.5 to 2 x 10^3 K. Active region brightnesses at the center are comparable with polar source brightnesses.

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