OBSERVATIONS OF SOLAR ACTIVE REGIONS AT 2 AND 6 cm WAVELENGTHS WITH 3 ARC SECOND RESOLUTION

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We have used the Very Large Array of the NRAO to observe solar active regions at 2 and 6 cm wavelengths in May 1979. In this paper we present and discuss the fine structure components of a sunspot associated radio region observed with a resolution of 3" arc on May 4 and 5, 1979. In this region (McMath 15974) there were two distinct groups of sunspots separated by about 3' arc. Group I located towards the west limb contained two spots while Group II in the east was a complex containing several spots that emerged during the period of our observations. At 6 cm both the sunspot groups were within the primary beam whereas at 2 cm only Group I was within the field of view. The VLA observations were made at 6 and 2 cm alternating between them every 5 minuts. The region was mapped with a resolution of about 3" x 3" using 10 hours of synthesis data on each day.

In Fig. 1 are shown the overlays of radio maps at 6 and 2 cm on the KPNO magnetogram for May 5. Similar overlays were also made for May 4. The brightest region at both 6 and 2 cm lies over the smaller spot on May 4, and over the larger spot on May 5. On May 4, there is good positional agreement between the 6 and 2 cm peaks associated with the smaller spot of Group I. However, on May 5, the 2 cm peak associated with the larger spot is displaced limbward with respect to the 6 cm peak. On May 4, the strongest peaks at 2 and 6 cm show significant circular polarization (50% at 2 cm, 30% at 6 cm), the polarity being consistent with that of the photospheric field of the smaller spot. However, on May 5, the 2 cm peaks show little circular polarization (10%) and are situated close to the neutral line separating the opposite polarities on the magnetogram. The 6 cm peaks also show little circular polarization (< 5%). The extended emission at 6 cm shows variations in circular polarization changing from left to right circular towards the limb, contratry to the change seen in the photospheric field.

In Fig. 2 is shown the overlay of the 6 cm map on the optical photograph of the sunspot Group II and magnetogram for May 5. On both May 4 and 5, peak brightness temperatures of 3.5 and 6.2 x 10^6 K respectively were observed over the southern part of the region associated with the

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emerging sunspot complex. An extended region of low brightness

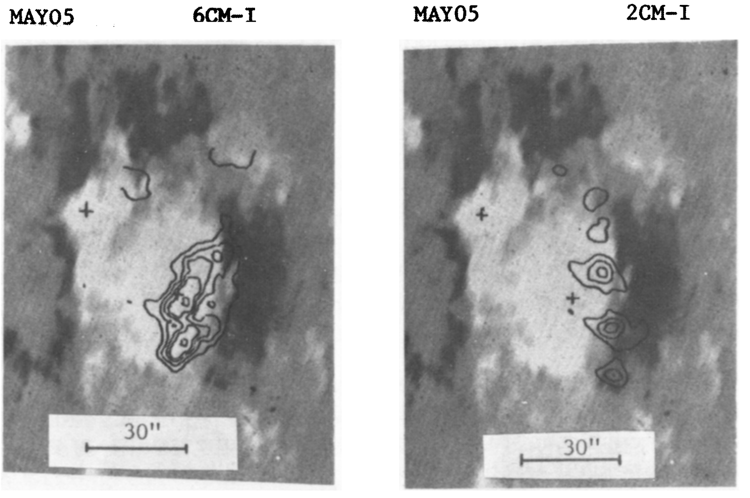
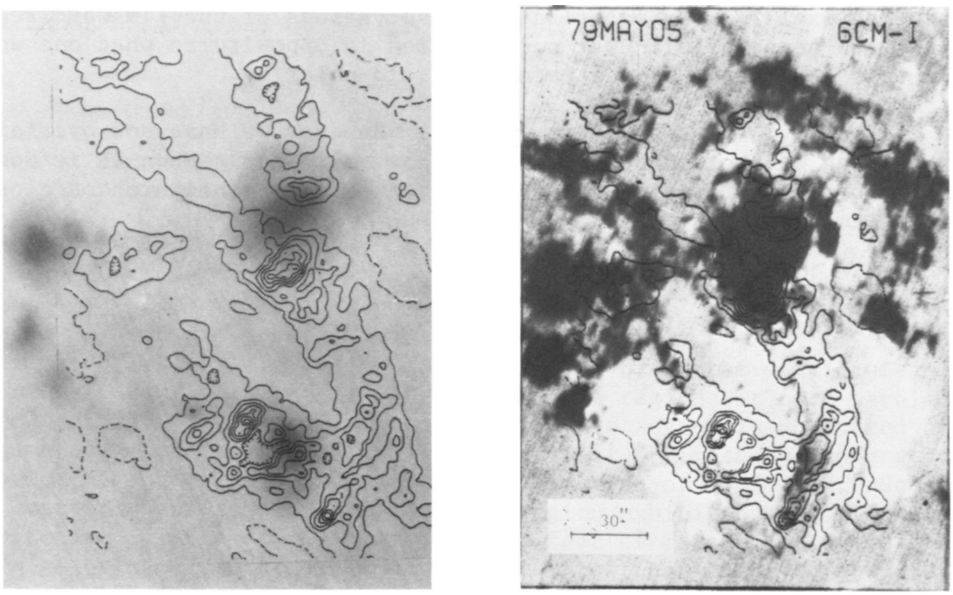


Figure 1. Overlay of the radio contour maps at 6 cm and 2 cm on the KPNO magnetogram containing sunspots in Group I (see text) on May 5, 1979. The 'cross' denotes the centers of the spots. The contour intervals are 540,000 and 45,000 K at 6 and 2 cm respectively; the highest contours are 3.24 x 10^6 K at 6 cm and 0.135 x 10^6 K at 2 cm. The size of synthesized beam is 3" x 3" arc at 6 cm and 4" x 3" arc at 2 cm.

appears to connect these various spots. This connection is seen more clearly in the low resolution (18" x 9") map not shown here. In the high resolution radio map shown in Fig. 2 the brightness distribution over the sunspot complex is fully resolved and the relative positions of the radio peaks with respect to the sunspots can be clearly seen. The brightest radio peaks do not coincide with the centers of any of the spots. In the case of the most prominent sunspots in the northwest, the strongest radio peak is displaced from the spot center by 20" arc on May 5 and by 30" arc on May 4, comparable to the size of its umbra (∿ 20" arc) and of its penumbra (∿ 40" arc). The displacement between the radio peaks and sunspot centers cannot be accounted for by the higher altitude (∿ 10000 km) of the radio emitting regions. A comparison of the 6 cm circular polarization map with the KPNO magnetogram shows that its overall distribution is consistent with the magnetogram. The region is bipolar with positive polarity over the southern spot and negative over the northern part of the complex. The extended emission and the distribution of peak emission between the two spot groups of opposite polarity seem to suggest that the 6 cm emission might originate from loops, similar to what one observes in x-rays and EUV.

Our results show that the centimeter emission from a sunspot is resolved into several bright regions. If this radio emission is the result of gyroresonance absorption in the corona, these bright regions must have



(a) (b)

Figure 2. Overlay of the radio map at 6 cm on (a) SPO heliogram in D_3 (b) KPNO magnetogram, containing the sunspots in Group II (see text) on May 5, 1979. The contour interval is 800,000 K. The size of the beam is 3\".5 x 3\".5 arc.

strong magnetic fields, a few hundred gauss; the overall brightness distribution at 6 cm seems to delineate a loop-like structure. The brightness temperatures of the regions range from 1.2 to 5.5 x 10^6 K at 6 cm and from 50,000 to 150,000 K at 2 cm. The corresponding angular sizes are ∿ 3" arc and ∿ 15" arc at 2 and 6 cm respectively. Although the structure of the sources around individual spots changed significantly between May 4 and 5, all the sources showed a steady increase in their brightness, part of which may be attributed to the increasing heliocentric angle, i.e. the angle between the sunspot magnetic field and the observer.

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DISCUSSION

Alissandrakis: You may have an inversion in the sense of circular polarization if the radiation passes through a Q.T. magnetic field region. This may explain your polarization observations of the limbward region, where the sense of circular polarization is opposite to what one would expect on the basis of the magnetic field polarity.

Velusamy: It could very well be. However we have not overlaid the underlying sunspot magnetic field on the radio map. When it is done we may have a better feeling about a magnetic field configuration close to the 6 cm source.