**STRUCTURE AND POLARIZATION OF ACTIVE REGION MICROWAVE EMISSION**

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**Abstract.** We present observations of active region radio emission at 6.16 cm wavelength, obtained with an angular resolution of 3" by 10" arc using the Westerbork Synthesis Radio Telescope (WSRT) during the action interval May 20–27, 1980 of the Solar Maximum Year (SMY). We present maps in both total intensity ($I$) and circular polarization ($V$) of three regions (Hale numbers 16850, 16863, and 16864) and provide a detailed comparison of these maps with on- and off-band Hα pictures and with magnetograms. The strongest sources were associated with neutral lines and soft X-ray arcades. We present evidence that these neutral lines were characterized by having their two opposite polarities close to each other, implying a high magnetic field gradient, and by their association with arch filament systems. The sunspot associated radio sources had a relatively simple structure in region 16850; however for the large spots of regions 16864 and 16863 the emission had a patchy appearance with a tendency of the peaks to lie over the penumbra. In the $V$ maps we observed for the first time two 'islands', polarized in the sense of the ordinary mode, which were located inside the sunspot associated sources and were associated with intrusions of opposite polarity field into the penumbra. These structures can be accounted for if the electron temperature along the line of sight is not a monotonically increasing function of height, but has a maximum near the second harmonic level. Finally we give a detailed analysis of observations of the inversion of the sense of circular polarization in region 16863. We find that the large scale structure of the magnetic field can be approximated by a dipole with its axis inclined by 11° with respect to the photosphere and with a dipole moment of about $2 \times 10^{31}$ cgs units; the depolarization line is located at a height of 0.16–0.19 $R_\odot$ above the dipole, where the estimated intensity of the magnetic field is 10–20 G.

**1. Introduction**

As part of the Solar Maximum Year (SMY) program of high resolution ground-based radio observations in support of the Solar Maximum Mission (SMM) experiments, we have carried out several periods of daily observations of active regions for as long as 8 days at a time with the Westerbork Synthesis Radio Telescope (WSRT). Perhaps the best observed period was May 20–27, 1980, when because of the Sun's high declination, active region maps of excellent quality could be obtained. Some results from the data obtained during this period have already been reported (Alissandrakis and Kundu, 1982; Strong et al., 1984; Alissandrakis and Kundu, 1984). The first two of these papers were concerned with the discovery of a ring structure in a sunspot associated 6 cm source, and its interpretation from combined X-ray (SMM-XRP) and microwave observations of the region. The third paper dealt with the center to limb variation of the structure of another sunspot associated 6 cm source and its comparison with the
computed brightness distribution, and consequential inferences about the morphology of the magnetic field in coronal regions. Besides these papers, there have been several other important publications in the recent past. For example, Schmahl et al. (1982) observed radio emission associated with an X-ray arcade between two spots of opposite polarity; they also concluded that large-scale currents must be present in active region loops to account for bright 6 cm sources far from sunspots. Also Lang and Willson (1982) presented additional evidence for the existence of ring/horseshoe structure in 6 cm sources associated with sunspots.

In the present paper, we present the maps in both total intensity and circular polarization of the other regions (Hale numbers 16864, 16863, and 16850) that were observed during this period. We consider it important to present all the maps obtained during this SMY period because of their excellent quality and their archival value to other ground based and SMM experimenters. Moreover, the large size of some of the sunspots together with the improved resolution (~ 3” by 10”) of the WSRT gave us the opportunity to study the fine structure of the sunspot associated sources. We also make a detailed study of these maps along with simultaneous Hα photographs obtained at the Athens Observatory and photospheric magnetograms from the Kitt Peak National Observatory and the Observatory of Meudon. This comparison has permitted us to make an in-depth study of the association of 6 cm radio emission with magnetic neutral lines as delineated by filaments or arch filament systems (AFS) as evidenced on Hα pictures. The observation of two of these regions over a six day interval gave us the opportunity to study the temporal changes in the 6 cm sources in association with the corresponding changes of the photospheric and chromospheric features, as well as the changes of the sources as their heliocentric position changed. Further, we provide a detailed discussion of the polarization inversion in the active regions and we discuss the origin of two ‘islands’ of apparently ordinary mode polarization which we observed within the large spots of regions 16863 and 16864; such islands are observed for the first time and they cannot be interpreted in terms of a simple polarization inversion.

2. Observing Procedure

The observations were obtained at 6.16 cm (4874 MHz, bandwidth 10 MHz) with the WSRT during May 20–27, 1980. Approximately twelve hours of observations were used daily to produce full synthesis maps in Stokes parameters I (total intensity) and V circular polarization) with an E–W resolution of 3′·6–4′·2 and a N–S resolution of 10′·0–12′·2. Sources that show time variations on a scale of less than 12 hr will be distorted in the maps (see Kundu et al., 1977); however most of the strong sources were found to be stable throughout the observing period. The shortest baseline was 54 m (877 λ), the longest 2718 m (44160 λ), making the instrument most sensitive to sources with E–W sizes between 2″ and 1′·7 and N–S sizes between 5′·8 and 5′·0. The baseline increment was 72 m (1170 λ) so that the innermost grating ring had a diameter of 6′·19 (E–W) by 17′·1 (N–S).