ON THE NATURE OF SOME ACTIVE REGIONS IN THE MICROWAVE RANGE

M. FELLI, G. TOFANI
Osservatorio Astrofisico di Arcetri, Florence, Italy

E. FÜRST
Max-Planck-Institut für Radioastronomie, Bonn, Germany

and

W. HIRTH
Institut für Radioastronomie der Universität Bonn, Germany

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Abstract. The radio emission of a selected number of solar active regions has been investigated with high angular resolution at two frequencies: 10 and 17 GHz.

By comparing the results of the two observations the following conclusions can be drawn:

1) The brightness temperature distribution of an active region is often composed of very bright cores of small dimension (angular extent $\theta \lesssim 20''$) imbedded in extended halos of lower brightness.

2) The radio emission of such structures as well as the degree of polarization can be explained with a thermal process. The halos can originate by pure thermal bremsstrahlung while in the case of the very bright cores found at 10 GHz (brightness temperature $T_b \approx 1-9 \times 10^6$ K) the emission at the harmonics of the gyrofrequency is needed.

1. Introduction

The radio emission of the slowly varying component, in the microwave range of the spectrum, is generally explained with the aid of three basic emission mechanisms. The pure thermal bremsstrahlung (i.e. in absence of magnetic fields) has been used to explain the weaker sources (Waldmeier and Müller, 1950; Christiansen and Mathewson, 1959). The high brightness temperatures and the presence of polarized emission in stronger sources (correlated with the presence of strong magnetic fields) were interpreted either in terms of magneto-ionic effects or as emission at the harmonics of the gyrofrequency (Zheleznyakov, 1962; Kakinuma and Swarup, 1962; Shimabukuro et al., 1973). These results were limited by the low angular resolution available in the past (1'–3'), i.e. the derived parameters have to be interpreted as mean values since they refer to the whole active region.

In the present work we report and discuss the observations of several active regions made with two high resolution instruments: at 10 GHz with the Stanford synthesis interferometer and at 17 GHz with the Bonn 100-m-dish, where also polarization measurements were available.

The comparison of the two observations points out a very complex structure in the active regions, which are preferentially composed of small bright components imbedded in weak extended sources. From the analysis of the observed parameters of each active region the possible type of emission mechanism investigated.

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The results indicate that:
(a) The strong bright components at 10 GHz may originate from gyromagnetic emission.
(b) Thermal bremsstrahlung in presence of magnetic fields might explain the emission and the polarization observed at 17 GHz.

2. The Observations

The observations were performed on September 1973; the active regions selected for the analysis are listed in Table I with their McMath numbers. The measurements at 17 GHz were made with the Bonn 100-m-telescope, the technical details of which can be found in Hachenberg (1970). At the frequency mentioned the half power beam width (HPW) of the dish is 50°. The method of observation, described in an earlier paper (Fürst et al., 1973), yields maps of the Sun with a spacing of the data points of 30°. The temperature resolution of the 17 GHz receiver was about ±10 K while the accuracy in the measurement of the polarization degree was within ±5%. No absolute calibration was available; the level of the quiet Sun’s emission was assumed to be 550 s.f.u. at 17 GHz (derived from Chiuderi et al., 1972). As an example of the observations, Figure 1 shows the complete map of the Sun in total power for 1973 September, 8. The 10.6 GHz observations were obtained with the Stanford X band interferometer (Bracewell et al., 1973). The use of this instrument for solar studies has already been described by Felli et al. (1974). The data are parts of a much vaster observing program carried out in cooperation with the ATM mission (Felli and Tofani, 1975). The interferometer was employed in the one-dimensional mode, where the observed brightness distribution of a field of sky, 4.2° wide, is reconstructed from the complex visibility function sampled in one integration time (typically of the order of 2 min). This operation is equivalent to the one-dimensional scan of the observed field with a fan beam, which has the maximum resolution in the east-west direction and the resolution of the single antenna in the north-south direction (16.1° × 7°). We remember that the instrument is a correlation interferometer, not too sensitive to the sources larger than the field of view (4.2°); then the one-dimensional scans will clearly show the fine structures present in the active regions but will attenuate the extended