N87-20888

VLA OBSERVATIONS OF SOLAR FILAMENTS AT 6 AND 20 CM WAVELENGTHS

M. R. Kundu
Astronomy Program,
University of Maryland
College Park, MD 20742

ABSTRACT

Using the Very Large Array we have observed several solar filaments at 1.5 and 5 GHz. The brightness temperatures of the filaments are 4-5 x 10^4 K at 20 cm and 1.5-1.6 x 10^4 K at 6 cm. The maximum temperature depressions appear to be associated with Hα filaments. Comparison with He 10830Å spectroheliogram shows that 20 cm temperature depressions correspond to the regions of reduced intensitiy in the He 10830Å around filaments, which correspond to coronal cavities. We have studied the temperature and density structure of the transition sheath between the filament and the surrounding corona assuming that the energy radiated away is balanced by the energy conducted from the corona. We find that the observations can be better explained by a model having a pressure gradient in the transition sheath around the filament.

OBSERVATIONS

At millimeter and centimeter wavelengths quiescent prominences appear as temperature depressions well correlated with Hα filaments (Kundu, 1972; Rao and Kundu 1977; Kundu et al 1978). Both radio and ultraviolet observations have suggested the existence of a transition sheath around the prominence where the electron temperature increases from the filament temperature to coronal values. Since microwave radiation originates in the transition region and the low corona, centimetric observations can provide a useful diagnostic on the coronal environment of a filament (Rao and Kundu, 1977). Most of the previous studies were limited to frequencies > 5 GHz. We carried out high resolution radio observations of filaments at 5 and 1.4 GHz, using the Very Large Array (VLA). The radio maps were compared with Hα and He 10830Å spectroheliograms. The observations were made on September 27 and 28, 1984 using the VLA in the D configuration (Kundu, Melozzi and Shevgaonkar, 1986). The array was used in a time sharing mode, alternately at 6 and 20 cm.

RESULTS

Figure 1 shows the 6 cm map superposed on the Hα picture of the region for September 27. The error in the superposition is estimated to be ~ 8". Radio temperature depressions are observed in the northern and southern part of the microwave active region associated with an Hα plage. The southern depression runs along an Hα filament. The width of the temperature depression is ~ 30"-40" and is larger than the Hα width (~ 10"-15"). The depression peaks are clearly associated

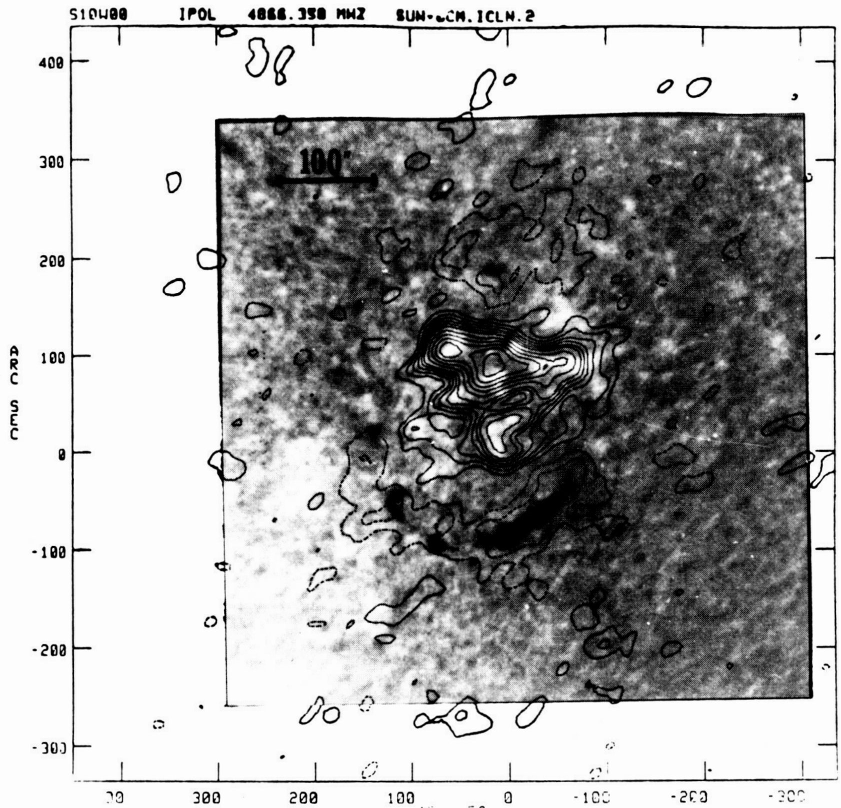

Fig. 1 6 cm map superimposed on the Hα picture of September 27, 1984 (courtesy of Scaramento Peak Observatory). The temperature contours indicate levels ranging from -970 K to 3.9×10^3 K with respect to the quiet Sun temperature.

with the Hα cold material. In the northern part of the Hα plage, the radio depression is ~ 100" wide. Although the maximum depression is located above the Hα filamentary structure on both September 27 and 28, a large part of the radio structure is not associated with any Hα feature.

In Figure 2, the radio map of September 28 is compared with the He 10830Å spectroheliogram. The 20 cm intense regions correspond well to the dark region of He 10830Å spectroheliogram; the regions of reduced intensity around the filaments are the filament channels which correspond to low density coronal regions (Harvey and Sheeley, 1977). Temperature depressions at 20 cm match these regions remarkably well. It is worth noting that although some radio emission voids are not associated with any particular Hα feature, they appear to overlie regions of reduced intensity in He 10830Å.

In Figures 1 and 2, we have identified a number of sources for which we have computed the brightness temperatures (T_b) on both days of observations. At 20 cm the average T_b's are 5.1×10^4 and 4×10^4 K on September 27 and 28 respectively. The main cause of uncertainity in these estimates is the assumed value for the average T_b of the quiet sun, T_{qs}. At 6 cm the observed T_b's are fairly constant and are consistent with previous observations (e.g. Chiuderi et al, 1975; Kundu et al, 1978).

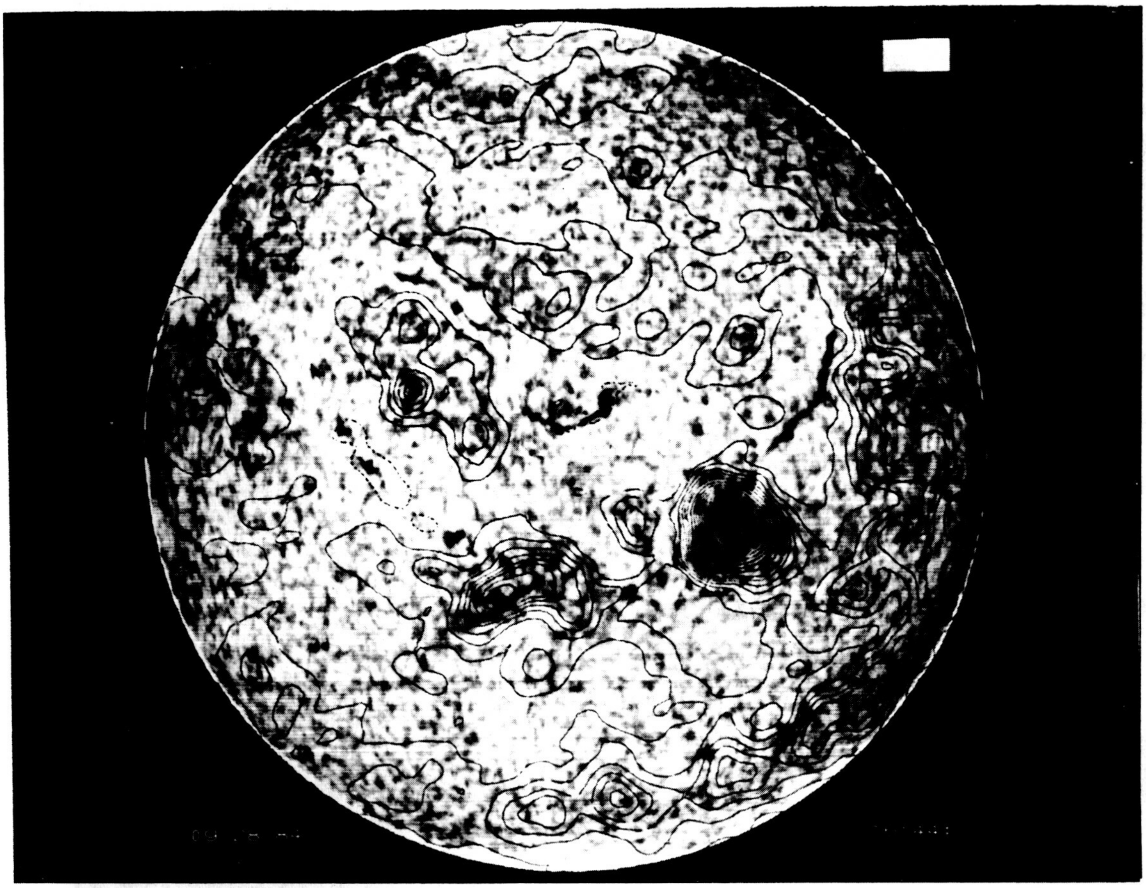

Fig. 2 Radio Sun at 20 cm of September 28, 1984, superimposed on the He 10830Å spectroheliogram (courtesy of J. Harvey). The temperature contours indicate levels ranging from $- 8.5 \times 10^3$ to 6.7×10^4 K with respect to the quiet sun temperature.

DISCUSSION

Our observations indicate that the radio filaments are larger in size than their optical counterparts. This implies that coronal cavity surrounding the filament leads to a broadening of the Hα filament in the radio band (Kundu 1972; Kundu et al 1978). The 20 cm temperature depressions coincide with the He 10830Å regions of reduced intensity, suggesting that the radio depressions are also related to regions of lower density and/or temperature in the corona. Indeed, the observed radio depression around a filament can be interpreted as due to reduced emission of a coronal cavity surrounding the filament. The observed difference in brightness temperature ΔT_b between T_{qs} and T_{cav} (the brightness temperature associated with the cavity) is $4\text{-}6 \times 10^3$ K at 20 cm and 150-450 K at 6 cm.

We have attempted to study the physical conditions in the transition sheath following the method first used by Rao and Kundu (1977). Following them we have assumed that the variation of temperature with height is determined by a balance between the thermal energy conducted in from the corona and the energy radiated away.

We find that our VLA observations can be fitted by assuming a constant pressure, P ≈ 1-3 x 10^{14} cm^{-3} K, confirming the previous optical estimates as well as the radio results of Rao and Kundu (1977). However, the fit is relatively poor at higher frequencies. A better fit at higher frequencies is obtained if we assume that in the transition sheath the pressure has a power law relation with the temperature (see Kundu, Melozzi and Shevgaonkar 1986 for details).

SUMMARY

1. The observed brightness temperature of filament cavities at 20 cm has an average value ~ 5.1 x 10^4 K and at 6 cm it is ~ 1.5 x 10^4 K.

2. The radio depressions have maximum values above Hα filaments. However the radio filaments are broader than their optical counterparts. At 20 cm the radio filaments coincide with lighter He 10830Å regions which probably correspond to filament cavities.

3. Although every Hα filament can be associated with a radio depression, the reverse is not true. However in the latter case, the radio depression seems to be associated with light He 10830Å regions.

4. In modelling the transition sheath between a filament and the corona, we have found that the energy conducted through the sheath is radiated away and no energy is conducted into the main body of the filament, confirming previous results of Rao and Kundu (1977). It seems that a model in which the pressure varies in the transtion sheath reproduces the observations more accurately than in the case of constant pressure.

This research was supported by NSF grant ATM 84-15388, NASA grant NGR 21-002-199, and NASA contract NAG 5511.

REFERENCES

Chiuderi-Drago, F., E. Fürst, W. Hirth, and P. Lantos, 1975, Astron. and Astrophys. 39, 429.

Harvey, J.W., and N.R. Sheeley, 1977, Solar Phys. 54, 343.

Hiei, E., 1985, private communication.

Kundu, M.R., 1972, Solar Phys. 25, 108.

Kundu, M.R., E. Fürst, W. Hirth, M. and Butz, 1978, Astron. Astrophys. 62, 431.

Kundu, M.R., M. Melozzi, and R.K. Shevgaonkar, 1986, Astron. Astrophys., in press.

Rao, A.P. and M.R. Kundu, 1977, Solar Phys. 55, 161.