FINE STRUCTURE OF THE SUN AT CENTIMETER WAVELENGTHS

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Abstract. The Hat Creek Observatory's two-element interferometer and the NRAO 3-element interferometer have been used at 1.3, 3.7- and 11.1-cm wavelengths respectively, to study the fine structure of the radio emissive regions on the Sun. Observations of the quiet Sun at 1.3 cm show sudden increases followed by a gradual decrease in the fringe amplitude lasting for typically about 5–8 min. Assuming these events are identical in nature, a plot of peak amplitude against the projected baseline at the time of the event suggests emission from a region of angular size of about 10″. The corresponding brightness temperature is 50000 K. It is possible that these events may be related to the appearance and disappearance of groups of spicules or mottles.

Observations at 3.7 and 11.1 cm were used to synthesize maps of the active region located at N14 W19 on 1973, June 8. The 11.1-cm map (Figure 1) exhibits three distinct peaks. The brightest components at both wavelengths do not seem to be completely

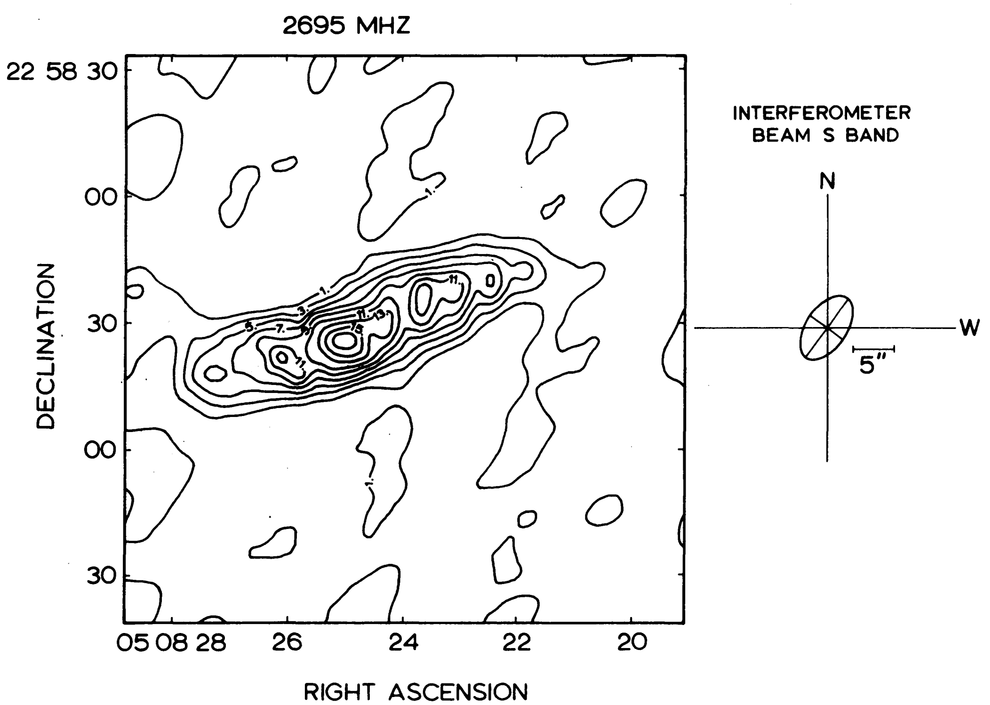

Fig. 1. Synthesized map at 11.1 cm of the region located at N14 W19 on 1973, June 8.

R. Grant Athay (ed.), Chromospheric Fine Structure, 65–68. All Rights Reserved.

resolved by the synthesized beams. The synthesized cleaned beams at 3.7 and 11.1 cm are elliptical gaussians of dimensions 3″.23 × 1″.62 and 9″.70 × 4″.82. There appears to be general agreement between the optical structures of the plage region and those of the synthesized maps. The maps imply that the plage regions contain bright points or cores along with diffuse areas or halos. The brightness temperatures of the strongest components are 8.4×10^5 K and 7×10^4 K at 11.1 and 3.7 cm, respectively.

On 1973, June 9, a flare associated burst was observed at 3.7 and 11.1 cm. The burst lasted for over 25 min. Figure 2 shows the fringe amplitudes during the flare at 3.7-cm

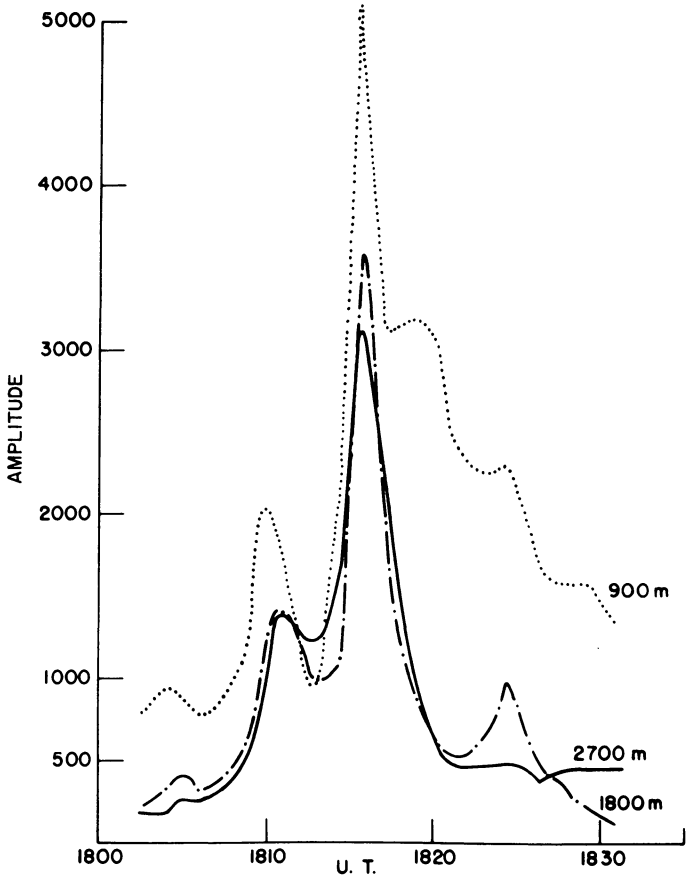

Fig. 2. Fringe amplitude in arbitrary units of the interferometer at 3.7 cm at all three spacings during the burst of 1973, June 9.

wavelength as a function of time. The interferometric records show a precursor from 18:05:5 to 18:12:5 UT followed by an impulsive phase with maximum at 18:15:5 UT. Comparing the fringe amplitudes at 3.7 cm to the visibility computed for model flare regions we found that the precursor data are best fitted by a region at 4″ in size while at the time of the peak, the flare appears to have a size of 2″. During the post-maximum

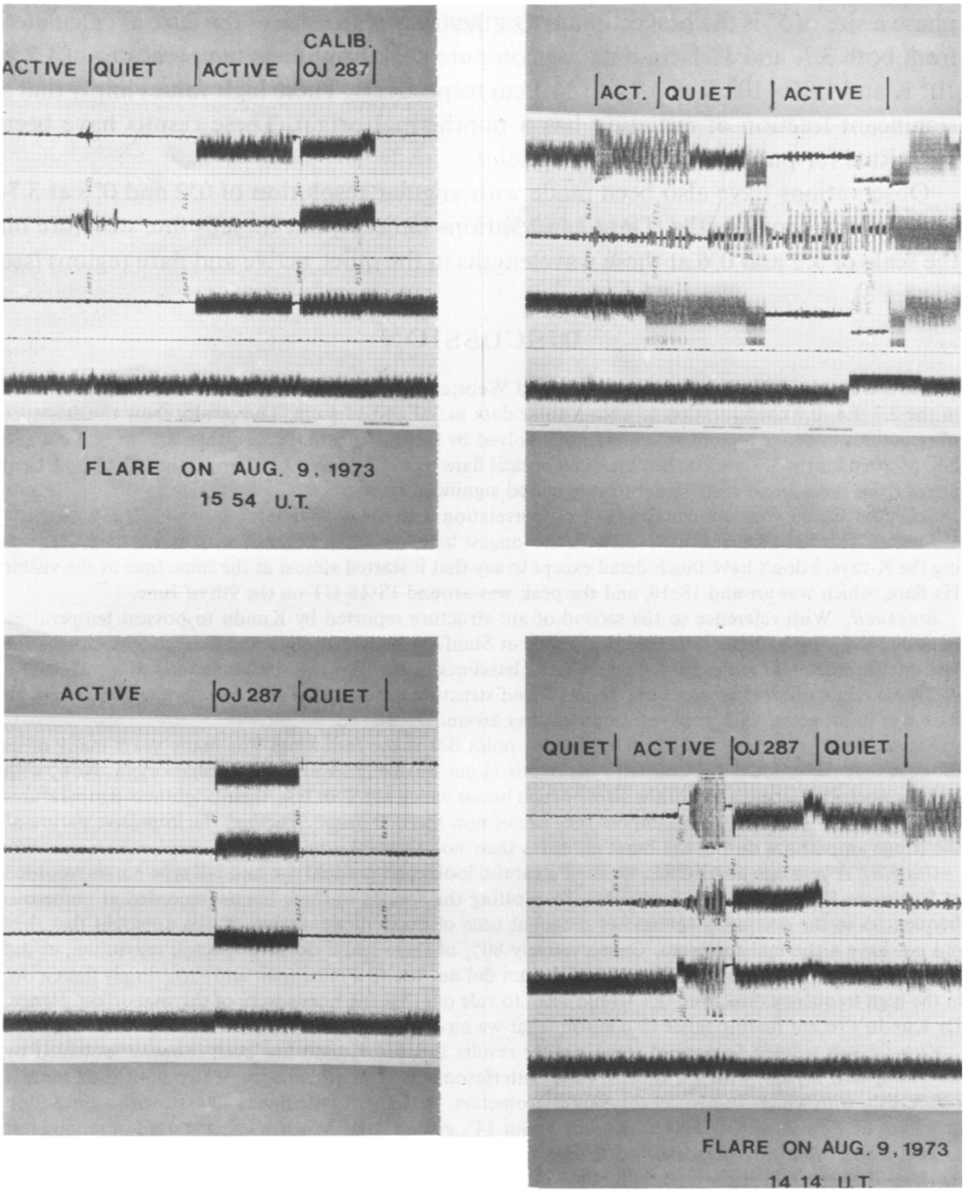

Fig. 3. Fringe amplitude output of the NRAO interferometer. Wavelength alternates every 30 s between 3.7 and 11.1 cm. Baselines displayed in each set are 1.8, 0.9, 2.7 and 35 km from top to bottom. Labels quiet and active refer to area of Sun producing fringes.

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phase a size of 5″ is the best estimate. On the basis of the size of the flare as calculated from both 3.7- and 11.1-cm data, we compute peak brightness temperatures of 1.2×10^9 K and 1.65×10^8 K at 3.7 and 11.1 cm respectively. These high values imply that a significant fraction of radiation has a nonthermal origin. These results have been submitted for publication to *Solar Physics.*

Observations have also been made with angular resolution of 0″.2 and 0″.6 at 3.7- and 11.1-cm wavelengths. These observations indicate that there is fine structure on the scale of 0″.2 and 0″.6 at these wavelengths in the quiet, active and flare regions (see Figure 3).

DISCUSSION

Brandt: Our group (Hobbs, Jordan, Maran and Webster) has used the NRAO 3-element interferometer in the 2.7–1.8–0.9 configuration to obtain solar data at 3.7 and 11.1 cm. The results show the existence of structures in active regions which are not resolved by the instrument, i.e. less than 8.5″ at 11.1 cm and 2.8″ (~2000 km) at 3.7 cm. At the time of an optical flare on 1972, November 2 and 3 the 3.7- and 11.1-cm fluxes from these small scale structures increased significantly.

Schmidt: Could you comment on the time correlation with the optical flare?

Kundu: This flare which I observed with the longest base line was associated with an Hα flare. Regarding the X-rays, I don't have much detail except to say that it started almost at the same time as the visible Hα flare, which was around 18:10, and the peak was around 18:16 UT on the 9th of June.

Bracewell: With reference to the second-of-arc structure reported by Kundu to possess temperature of 50000 K I wish to report observations made at Stanford University by John Grebenkemper with the fast interferometer which enables nine different baselines to be observed simultaneously at a wavelength of 2.8 cm. On a number of occasions he has found structure around 5″ in size, in active regions where no flare was in progress, with apparent temperatures around 7×10^6 K.

Kundu: One important thing that I'd like to point out is the following. For many years many of us thought that the gradual rise and fall type bursts at cm wavelengths were of thermal origin. Now, with interferometric determination of the sizes of such bursts which are 2″ or less, their brightness temperatures are found to be $\sim 10^9$ K, which implies they are of non-thermal origin. Further, the impulsive nature of the fringe amplitudes during the burst indicates their non-thermal origin.

Castelli: A year ago at AFCRL, we took a careful look at all gradual rise and fall type bursts recorded at Sagamore Hill for three or four years. By plotting the spectra of these bursts (recorded at numerous frequencies in the decimeter-centimeter range) at time of maximum emission, it was apparent that they did not have a thermal spectrum. Conservatively 80% of them had a decisive spectral maximum, as did the obviously impulsive bursts. Since the spectrum did not rise to a maximum and then simply flatten out in the high frequency direction, this would seem to rule out that the bursts were of thermal origin. Hence, Dr Kundu's recent finding tends to confirm what we already suspected.

Zirin: I just wanted to present some similar results to what Kundu has been showing, obtained by Ken Lang and myself, with the Owens Valley interferometer. This is made up of two 90-ft dishes and a 130-ft dish, with which we can get three interferometers, the longest base line is 4000 ft, with a resolution at 3.7 cm of 7″, and with a 1600-ft base line about 14″, give or take. When we first started observing last December we were extremely pleased to find that with a 1600-ft base line we found, as Kundu has remarked, that the Sun is covered with small elements which show fringes. Later on in the first run, we obtained a couple of flares which showed a strong enhancement of fringe intensity, again with a 1600-ft base line. In December we were able to use the 4000-ft base line, and found that, although there were fringes with the 1600-ft base line at about 13″, we could see no fringes with the 4000-ft base line, not even in active regions. However, during this period we began to see fringes with 7″ fringe spacing, and then a flare occurred which gave a large enhancement of these fringes as well as phase shift. In addition, there were rather sharp phase shifts and we noticed that they were associated with separate spikes in the burst. One might imagine that what we are seeing is separate lights twinkling on and off and we get phase shifts due to their different positions.