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13. ABSTRACT (Maximum 200 words)

During this first year we have concentrated on the analysis, and the image enhancement and processing of an extensive set of the EUV/Skylab data for the search of empirical characteristics of coronal heating in different scale magnetic regions on the Sun. Student involvement in our research projects has been quite successful. These students are Martina Arndt, Fred Blundell, Amy Mossman, Gretchen McPhee and Eric Woods. During this funding period we have also collaborated with Prof. You Qin Hu, from the University of Science and Technology of China, who visited the Solar and Stellar Physics Division for three months, and with Dr. Ruth Esser who has recently joined the Division as a physicist.

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HIGH RESOLUTION STUDIES OF THE STRUCTURE OF THE SOLAR ATMOSPHERE

Air Force Grant AFOSR-91-0244

Annual Report No. 1

For the period 1 July 1991 through 30 June 1992

Principal Investigator

Shadia R. Habbal

July 1992

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HIGH RESOLUTIONS STUDIES OF THE STRUCTURE OF THE SOLAR ATMOSPHERE

ANNUAL REPORT

For the Period July 1, 1991 to July 31, 1992

1. Introduction

During this first year we have concentrated on the analysis, and the image enhancement and processing of an extensive set of the EUV/*Skylab* data for the search of empirical characteristics of coronal heating in different scale magnetic regions on the Sun. Student involvement in our research projects has been quite successful. These students are Martina Arndt, Fred Blundell, Amy Mossman, Gretchen McPhee and Eric Woods. During this funding period we have also collaborated with Prof. You Qiu Hu, from the University of Science and Technology of China, who visited the Solar and Stellar Physics Division for three months, and with Dr. Ruth Esser who has recently joined the Division as a physicist.

2. Summary of Accomplished Research Projects

2.1 Characteristics of the Temporal Variability of the Emission

We studied the temperature dependence and location of the variability in active regions. We found that the variable emission in an active region occurs preferentially around the footpoints (Figure 1). The magnitude and spatial density of the variability is temperature dependent with a peak at 7.4×10^4 K. The temperature dependence of the variable emission from an active region is very similar to that in a quiet region and a coronal hole (Figure 2). These results are a strong indication that the small scale field is greatly responsible for the variable emission of the solar atmosphere, and that whether in closed structures such as active regions or the quiet sun, or in open structures such as coronal holes, the large scale field plays a more passive role in the coronal heating process.

By applying IDCON, an algorithm that allows both the high resolution image and the degrading point spread function to be recovered from high signal-to-noise images, to the active region data, we were able to produce images with at least twice the resolution (Figures 3 and 4). The processed images show the presence of fine scale structure in active regions at all temperatures, in support of the results of the data analysis described above. We will be using the processed images to determine the nature of the spatial correspondence, if any, between variations at different temperatures.

2.2 Studies of the Small Scale Structure at the Solar Limb in Coronal Holes

A new image enhancement algorithm, MADMAX, developed by Koutchmy et al (1987), has been applied to limb observations in a coronal hole (Figure 5). The algorithm replaces each pixel in an image by the second derivative of the intensity, maximized over eight directions. Several levels of block-average smoothing may be applied prior to the derivative, and the results may be blended to emphasize features at various scales. By applying this technique to limb observations, we find that there is a fine scale structure, with a characteristic spatial scale of 10", extending from the solar limb outwards into the corona (Figure 6). In addition, we find that different temperature fine structures which have the same spatial characteristics are not cospatial.

2.3 Inferrence of Coronal Temperatures

Line intensity ratios from EUV/*Skylab* limb observations in a coronal hole were used to infer the temperature in a coronal hole. We showed that the coronal base temperature, which is a critical parameter for solar wind models, cannot be determined with existing observations, to an accuracy better than 5×10^5 K.

2.4 Acquisition of Coordinated Ground-Based Observations

An international set of coordinated ground-based observations have been recently obtained on July 23, 24, to study the solar wind from its source region into interplanetary space. The instruments involved were the Very Large Array (VLA), the vector magnetogram in Hawaii, and the EISCAT radar system in Scandinavia to obtain Interplanetary Scintillation (IPS) measurements. The goal of these observations is to determine solar wind plasma parameters at the base of a stream (with the VLA) and in interplanetary space (with IPS).

3. Publications and Presentations

3.1 Publications

M. Arndt and S. R. Habbal, "Comparison between the Characteristics of the Variable Emission in Active Regions and the Quiet Sun", manuscript in preparation.

M. Arndt, A. Mossman and S. R. Habbal, "Temperature Dependence of the Spatial Variability of the Emission from Active Regions", manuscript in preparation.

S. R. Habbal, "Coronal Energy Distribution and X-ray Activity in the Small Scale Magnetic Field of the Quiet Sun", *Annales Geophysicae*, **10**, 34, 1992.

S. R. Habbal, "Variable EUV emission in the Quiet Sun and Coronal Heating", in *Cospar Colloquium on Solar Wind Seven*, E. Marsch and R. Schwenn (eds.), Pergamon Press, in press, 1992.

S. R. Habbal and R. Gonzalez, "First Observations of Macrospicules at 4.8 GHz at the Solar Limb in Polar Coronal Holes", *Astrophys. J.*, **376**, L25, 1992.

S. R. Habbal, R. Esser and M. B. Arndt, "How Reliable are Coronal Hole Temperatures Deduced from Observations", submitted to *Astrophys. J.*, May 18, 1992.

Y. Q. Hu and S. R. Habbal, "Interaction between Perpendicular MHD Shocks", submitted to *Phys. Fluids B: Plasma Phys.*, June 20, 1992.

Y. Q. Hu and S. R. Habbal, "Double Shock Pairs in the Solar Wind", submitted to *J. Geophys. Res.*, July 20, 1992.

M. Karovska, F. Blundell and S. R. Habbal, "Fine Scale Structure of Active Regions", manuscript in preparation.

M. Karovska, F. Blundell and S. R. Habbal, "Fine Scale Structure of the Solar Limb in a Coronal Hole", manuscript in preparation.

3.2 Conference Presentations

M. B. Arndt, A. Mossman and S. R. Habbal, "Temperature and Spatial Dependence of the Variable Emission from Active Regions", Poster Presentation, Gordon Research Conference, Plymouth, New Hamphire, July, 1992.

S. R. Habbal and R. Esser, "Temperatures and Densities in the Inner Corona", Poster Presentation, 180th AAS Meeting, Columbus, Ohio, June, 1992.

3.3 Invited Talks

S. R. Habbal, "Variable EUV Emission in the Quiet Sun and Coronal Heating", Invited Talk, Solar Wind VII Conference, Goslar, Germany, September, 1991.

S. R. Habbal, "Activity in the Quiet Sun", Physics Colloquium, Rensselaer Polytechnic Institute, April, 1992.

S. R. Habbal, "Observational Characteristics of Solar Activity in Small-Scale Magnetic Structures", Invited talk, Gordon Research Conference, Plymouth, New Hampshire, July, 1992.

4. Future Projects

We will be concentrating on several research projects which involve data analysis, image processing and theoretical modelling:

Comparison of the temperature in coronal holes and the quiet sun: the implication for solar wind models. This study will be based on the analysis of an extensive set from the EUV/*Skylab* data of limb and disk observations. These studies will be complemented by theoretical solar wind models.

The energy spectrum of the variability of the emission in active regions, the quiet sun, and coronal holes. This study will also involve the analysis of an extensive set from the EUV/*Skylab* data.

Studies of the fine scale structure in the quiet sun and active regions. These projects will involve the application of IDCON and MADMAX on a large data set to establish the difference, if any, between the fine scale structure in large and small scale magnetic structures such as active regions and coronal bright points. The goal is to find a characteristic underlying scale for the magnetic field structure.

Model radio emission in the presence of structure in the quiet sun and active regions. The inference of plasma parameters from radio observations is often based on very simplifying assumptions. We plan to make a model/parameter study of different magnetic regions, compute the brightness temperature from the modelled plasma parameters, and compare with observations. The goal is to establish the role of small scale structure in the interpretation of radio observations.

Propagation and damping of MHD waves in the presence of structure in coronal holes. This theoretical project will be carried out by a graduate student, Eric Woods, whose support started in July with the accompanying AASERT program.

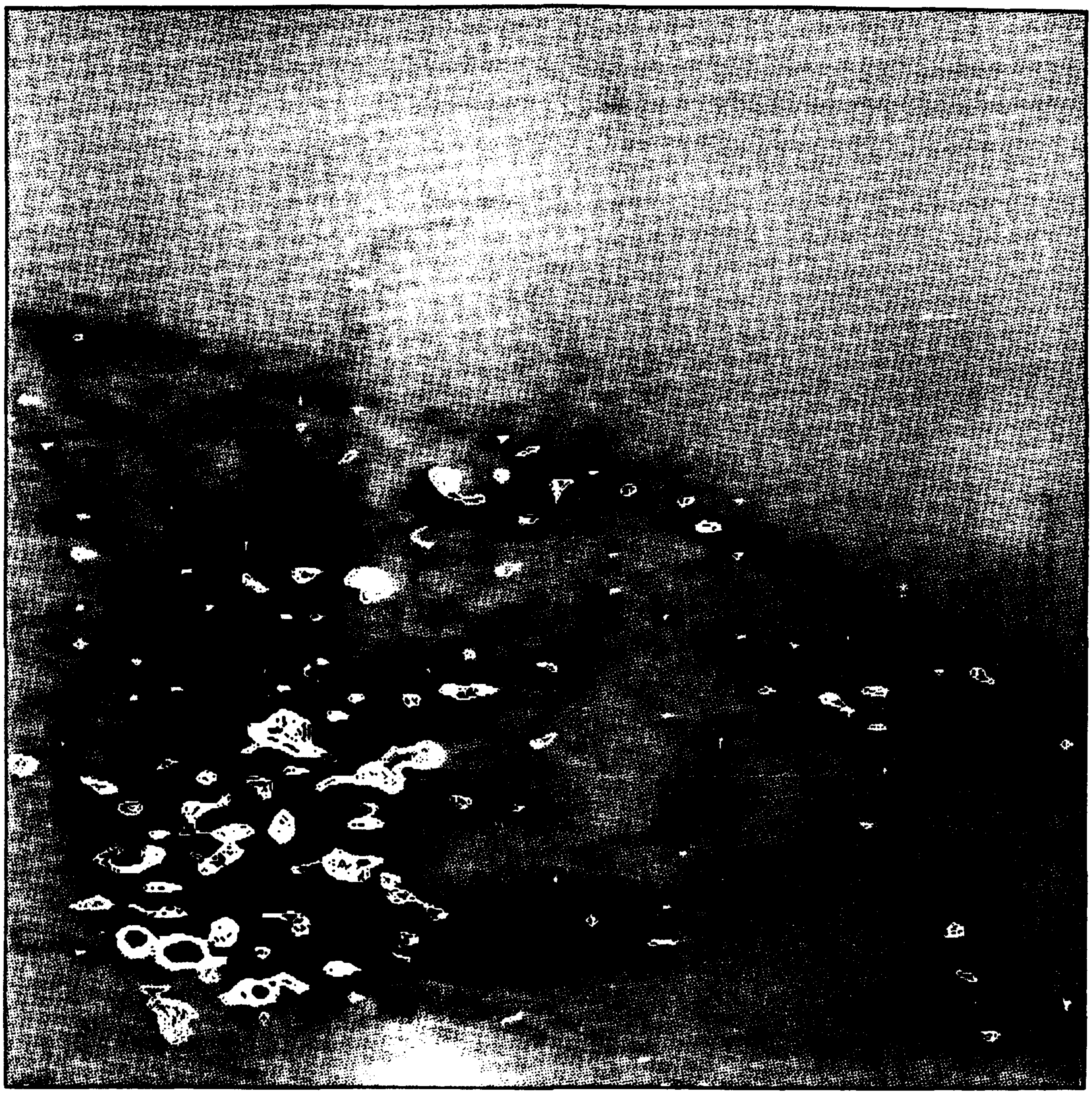

Figure 1. Grey scale image of an active region on the disk and one close to the limb, within the same field of view of 5×5 arcmin, taken in the Ne VII 465 Å line formed around 5×10^5 K. The white contours represent the location of the significant variable emission as derived from the difference between two consecutive rasters 5.5 minutes apart.

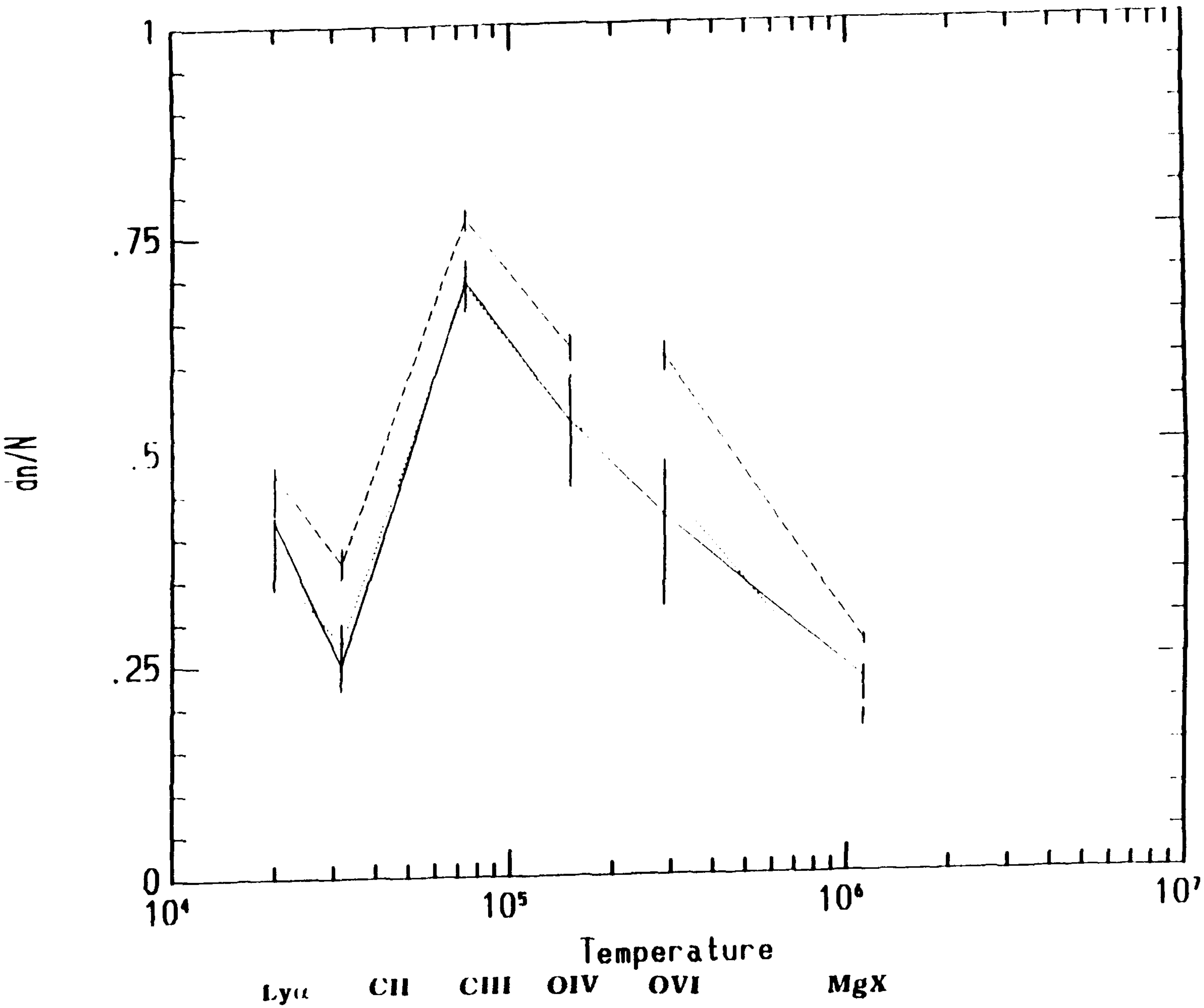

Figure 2. The spatial density $\frac{\delta n}{N}$ of the variable emission as a function of temperature. The vertical bars indicate the empirical spread of this measure as a function of time. The dashed curve is for the active regions shown in Figure 1, the dotted curve is for a quiet region, and the solid curve is for a coronal hole.

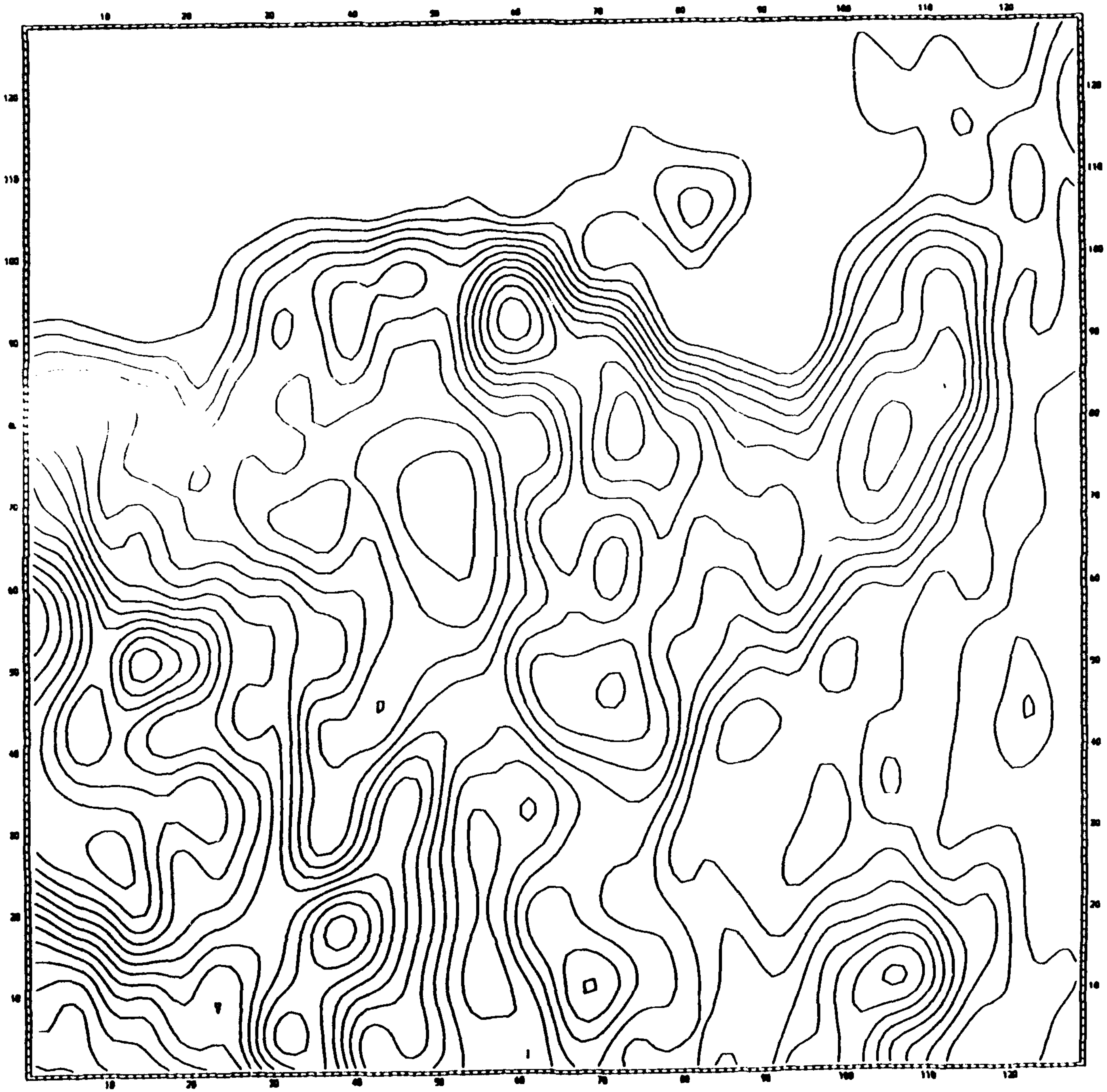

Figure 3. Contour plot of a section of the active region that appears on the disk in Figure 1 [illegible] in Mg X 625 Å formed around 1.12×10^6 K

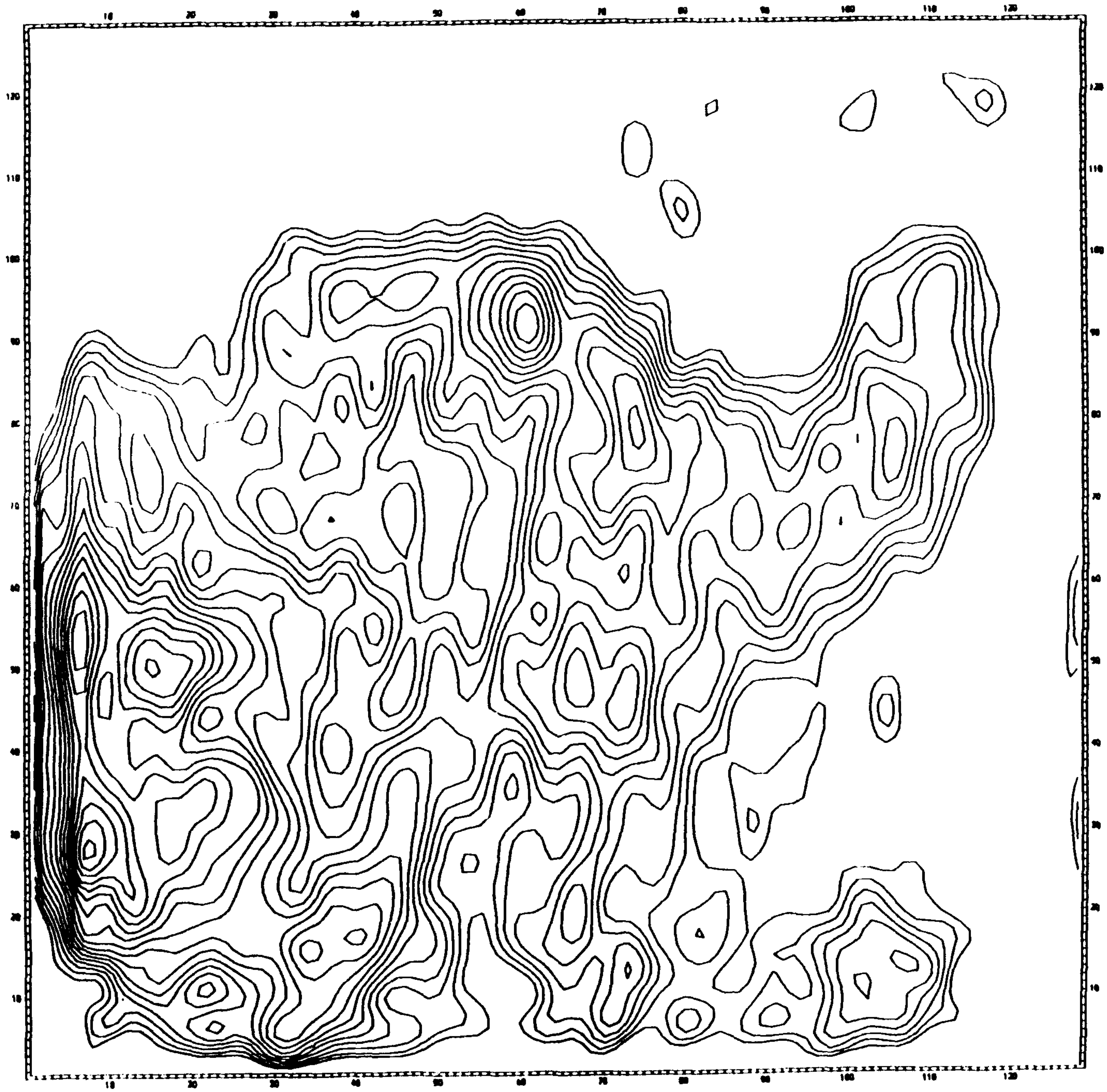

Figure 4. Contour plot of the image processed with IDCON, of the same section of the active region as in Figure 3. The spatial resolution is increased by a factor of two.

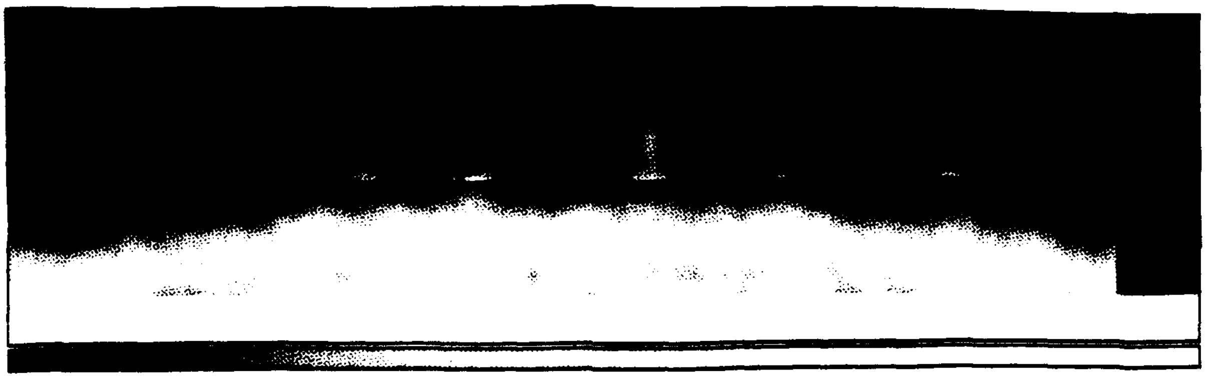

Figure 5. Observations of the limb in C III 977 Å formed at 5.410^4 K. The field of view is 5×1 arcmin. The most structured features extending beyond the limb, in the vertical direction are macrospicules, which are preferentially observed at C III. A mask has been applied to the disk portion of the image to reduce the disk intensity which is 100 times stronger than the emission off the limb.

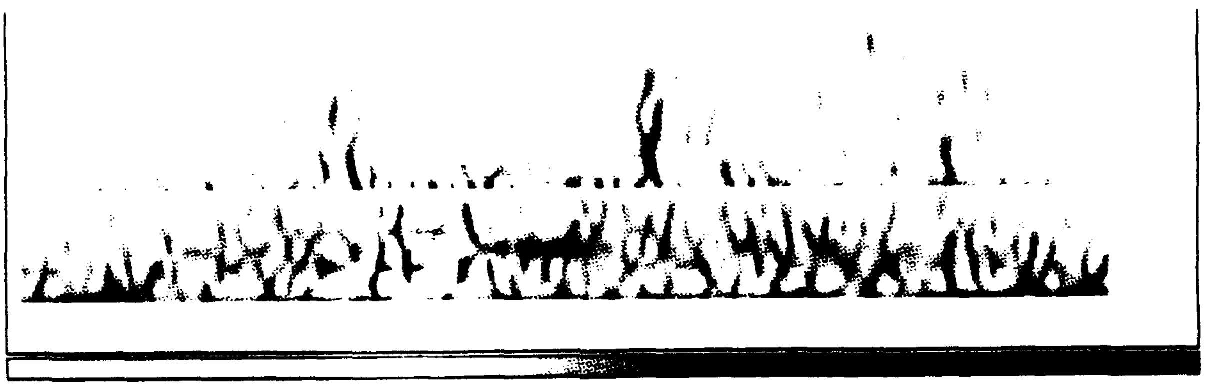

Figure 6. Same region as shown in Figure 5, after the application of MADMAX. The most striking feature is the appearance of filamentary structures that extend beyond the surface with a characteristic separation scale of 10".