PREPARING FOR SOHO: RESULTS FROM THE TRANSITION REGION CAMERA

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ABSTRACT

In the course of the five rocket campaigns including the Transition Region Camera (TRC) from 1979 to 1992, we obtained multi-band solar images with ~ 1" resolution in the Lyo and CIV lines, and in the UV continua at 160 nm and 220 nm. Coordinated observations of flares, eruptive prominences, coronal and post-flare loops were obtained and we describe here some related results. These studies can be used in defining and preparing coordinated observing sequences for the SOHO mission.

Keywords: Sun, ultraviolet emission, corona, transition region, SOHO

1. INSTRUMENTATION AND OBSERVATION

The Transition Region Camera (TRC) is a rocket launched instrument which records solar ultraviolet monochromatic filtergrams /1-5/. It consists of a 10.6 cm telescope with 4 selectable broad band interference filters (centered on a choice of wavelengths, i.e. 121, 155, 157, 162, 169 or 220 nm depending on the flight). A series of exposure times and filter wheel positions were programmed and commanded through an electronic sequence, enabling correct exposures. The full disk filtergrams were recorded on special photographic films (Kodak 101-01 or Kodak 104). The flights of the TRC mission took place at the White Sands Missile Range (July 3, 1979, September 23, 1980, July 13, 1982, October 25, 1985). A Nike boosted Black Brant rocket was used, culminating at an altitude of 300 km, allowing about 5 minutes of useful ultraviolet observations with the TRC.

2. THE TRANSITION FROM PHOTOSPHERE TO CORONA

The extensions of fine scale magnetic fields associated with supergranular network can be traced to different heights with high resolution images such as those obtained with TRC, from the middle photosphere (220 nm), to the temperature minimum (160 nm), the 20 000 K base of the transition region (Lyo) or to the 100 000 K region (CIV). Plages show up on 220 nm and 160 nm filtergrams with an excess brightness of 80-120 K and 120-300 K, respectively. A cross-correlation analysis indicates a bimodality of the flux distribution, as expected from a mixture of regions with and without magnetic elements i.e. quiet Sun and active regions. Up to the temperature minimum, TRC observations of network elements are consistent with a thin flux tube model in hydrostatic and thermal equilibrium with its surroundings, diverging with height from photospheric values of the magnetic field \( B_0 = 1.2 \text{kG} \), and radius 150 km /1, 2/ (Foing and Bonnet 1984, Foing et al. 1986). In order to put constraints on models of the solar corona including the variation of the geometry of flux tubes with height, the energy balance and dynamics, and to understand how magnetic fields merge into chromospheric canopies and coronal loops, we need more ultraviolet observations at high spatial resolution. The coronal instruments on SOHO will give much information to help resolve these problems.

3. FINE CORONAL STRUCTURES

Coronal loops observed by TRC at the limb and on the disk in Lyo and CIV /3-6/ (Bonnet et al. 1980, Foing et al. 1986, 1988) show the coexistence of multi-temperature plasmas. On Lyo filtergrams, threadlike structures extending out of active regions or crossing the network boundaries, delineating magnetic field lines, are observed both in absorption and in emission on the disk, indicating a very heterogeneous distribution of plasma temperature and density. On overexposed images, spicule or loop structures can be measured well above the limb. For instance, raster scans of a Lyo filtergram at the limb illustrate the emission of network components with a scale height of 1500km. They also show a weaker emission extending 10 – 20" above the network boundaries, revealing plasma along magnetic field lines protruding from the chromospheric network (see Figure 1). Spectroheliograms obtained with SUMER on SOHO should allow to diagnose these fine structures.

4. FLARES AND INSTABILITIES

Dynamic phenomena such as flares, filament eruption or post-flare loops were studied using TRC.
multiband filtergrams. During a M1 X-ray class flare on July 13, 1982, a X-ray spectrogram was taken between 8 and 97 Å, covering lines with a range of ionisation temperatures from 7 \times 10^6 K (Ne VIII) to 7 \times 10^9 K (Fe XIX) (Acton et al. 1985). The geometry could be traced using simultaneous TRC filtergrams, and the dynamics and radiative output of related flare structures, such as flare kernels and a twisted eruptive filament could be studied. From the multiband diagnostics, an energy budget was derived for the different components of the flare. One sees that a similar observing strategy with SOHO observing fast time filtergrams with EIT, in support of UV spectroheliograms or rastered spectra will give insight on the dynamics and energetics of microflares, flares, mass ejections and other heating phenomena.

5. RESULTS ON Lyα AND Hα FILAMENTS

The physical parameters in the solar atmosphere vary on a large scale with altitude, but also on a small scale within different structures. Using high resolution observations in different wavelength regions it is possible to examine the distribution of the physical parameters on small spatial scales. With this in mind we have compared UV images obtained with the TRC, with Hα spectroheliograms from Sacramento Peak Observatory.

In Figures 2 we show images in Lyα (TRC) and Hα (Sacramento Peak) of the long filament and the prominence at the NE limb. The filament consists of three parts F1, F2 and F3 with distinct physical properties. F1 is very dark and similar in both Lyα and Hα. F2 can be seen in its full length in Lyα, but is fragmented in Hα. F3 is seen in Hα, but not in Lyα.

A statistical analysis based on Lyα and Hα intensities confirms this distinction between different regions. Figures 3 show two dimensional cluster histograms between Lyα and Hα for the active region A and the filament region B, respectively. From these histograms one notes that the quiet Sun component shows a negligible variation in Hα for a significant increase of Lyα associated with a contrasted chromospheric network. The cluster of points corresponding to the dark filament structures shows a loss of correlation between Lyα and Hα, and thus inhibits no typical Lyα/Hα ratio (Figure 3, bottom). The histogram of the active region A shows the correlated emission of Lyα and Hα in plages (Figure 3, top).

These observations suggest that the radiative properties of the plasma vary from filament to filament and also along the same filament channel. This might be a signature of the different states of activity these filaments are experiencing /7/, which would influence local parameters like temperature and densities, and therefore the NETE radiative transfer /8/.

A comparison between Lyα images obtained with the Transition Region Camera and Hα images obtained at Sacramento Peak Observatory and Meudon Observatory shows that there is generally a good cor-
relation between the intensities of the two lines in plages. However, for some structures like the chromospheric network and filaments the intensities do not correlate well. This is an indication of the different distributions of physical parameters of filaments in different states of activity. These results should be followed up with a similar analysis using SOHO multispectral data.

ACKNOWLEDGEMENTS

We thank Drs. R. M. Bonnet who built TRC, and M. Bruner for the coordination of the XSST/TRC rocket campaigns. We thank the staff of LPSP, LPARL and White Sands for their support to this programme.

REFERENCES

Figure 3: Cluster histogram between Lyα and Hα intensities. The quiet Sun component (QS) of the regions A (top) and B (bottom) shows little variation in Hα intensity for a range of Lyα intensities. In the plage (top), the Hα intensity is better correlated with the Lyα intensity. In the filament component (bottom), one measures a loss of correlation between Lyα and Hα, suggesting structures with a large range of Lyα/Hα ratios and reflecting the inhomogeneous distribution of physical parameters in prominences.