COMBINED HRTS-8 SOUNDING ROCKET OBSERVATIONS AND YOHKOH SOFT X-RAY OBSERVATIONS OF NOAA ACTIVE REGION 7260 AT THE SOLAR LIMB

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Abstract

On 24 August 1992, the Naval Research Laboratory (NRL) High Resolution Telescope and Spectrograph (HRTS) was launched aboard a Black Brant sounding rocket from White Sands, New Mexico. During the flight, the instrument recorded a unique set of near ultraviolet slit spectra and 1550 Å spectroheliograms of an active region at the solar limb. An extensive set of observations of this region were obtained with the Yohkoh Soft X-ray Telescope (SXT) near the time of the flight. The C IV spectroheliograms obtained during this flight are some of the highest resolution images of the solar transition region ever obtained. The spectra and spectroheliograms dramatically demonstrate the fundamental difference between coronal and chromospheric/transition-region plasmas at 700 km spatial scales. The cooler plasmas exhibit a great deal of dynamic, fine scale structure with significant flows or proper motion particularly in the transition zone loops. The coronal emission lines in the spectra are relatively uniform and quiescent. The Yohkoh data during the period before and after the flight show a set of diffuse high temperature coronal loops with only minimal correspondence to the structures visible in the C IV spectroheliograms.

1. Introduction

For the eighth HRTS rocket flight, the instrument underwent a substantial modification from its usual configuration. The telescope configuration was changed from Cassegraine to Gregorian; a Lyot stop and solar occulter was installed in the telescope to reduce scattered light above the limb. New gratings were installed in the tandem Wadsworth spectrograph

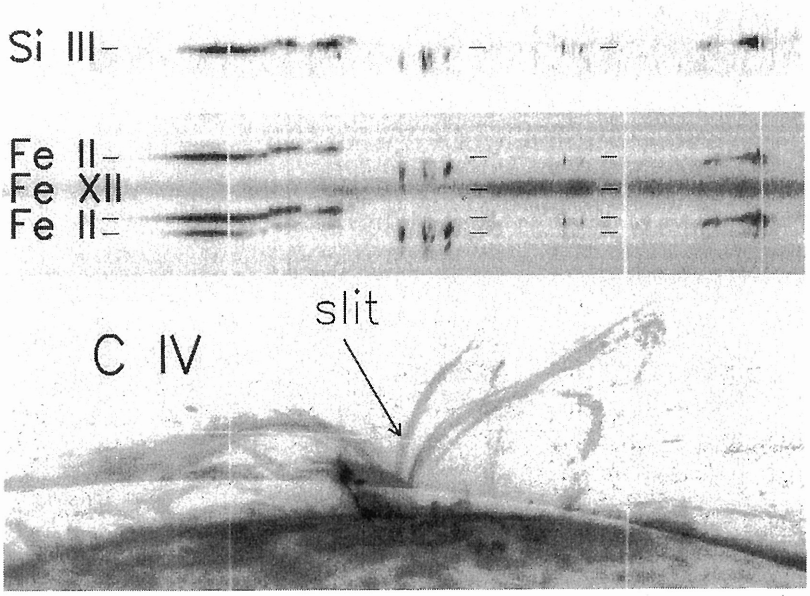

Fig. 1. A typical C IV spectroheliogram and line profiles of Fe II, Si III and Fe XII recorded during the HRTS-8 flight.

(described in Bartoe and Brueckner, 1975) to shift the spectral range from 1200-1700 Å to 1850-2650 Å. The double dispersion spectroheliograph (described in Bartoe and Brueckner, 1978) bandpass was shifted from 1600 to 1550 Å to obtain C IV images above the limb. A curved, reflective slit jaw was installed to obtain spectra above the limb at similar coronal heights. Different reflective coatings were utilized on the slit jaw resulting in similar spectroheliograph exposure times for imaging limb and disk plasmas. Real time targeting and focusing of the payload was accomplished using the Hα slit jaw video imaging system.

HRTS-8 was launched from White Sands, New Mexico on 24 August 1992 at 1630 UT aboard a Black Brant rocket. Following target selection and telescope focusing, six exposure sequences were run. In each sequence, a range of spectrograph, spectroheliograph and Hα exposures were taken at fixed pointing position. The curved slit was oriented nearly parallel to the limb, approximately centered on NOAA active region 7260. The first sequence placed the slit about 60" inside the limb to determine an absolute calibration for the data set. Subsequent slit pointing moved outward from the solar limb. Active region 7260 was just inside to west solar limb at roughly north 15 degrees on August 24 during the flight. The Yohkoh SXT images showed strong soft x-ray emission throughout the disk passage of the active region. On the day of the flight, no major flares were reported in the region. The largest X-ray flare was a GOES class C9 at 1000 UT. No significant soft x-ray activity occurred during the HRTS-8 rocket flight.

2. A subset of CIV spectroheliograms and near UV spectra obtained during the HRTS-8 flight

Figure 1 shows the general appearance of the active region in C IV (lower image) and resulting co-aligned slit spectra. The position of the curved slit is located just above the image discontinuity caused by the change in slit jaw reflectivity from lower (bottom) to higher (top). The positions of the fiducial wires on the slit are seen as lines that intersect the solar limb. The active region was located approximately at the west limb; solar north is to the left in the images. The image above the limb is dominated by filamentary C IV structures that appear to be more closely related to prominences such as commonly seen in Hα than to coronal structures.

The ultraviolet slit spectra in Fig. 1 include lines of Fe II, Si III(1892.03 Å) and Fe XII(2405.67 Å). The spectra are displayed such that a redshift (motion away from the observer) is displaced toward the top of the figure (away from the spectroheliograph image). The short horizontal lines mark the rest wavelengths of the observed lines. The height of the slit above the limb in Fig. 1 is about 72 Mm(100") in the area of the surge. Using the fiducial wires and the C IV slit jaw images, the spectra spatial position along the slit were co-aligned with the C IV structures and disk position. The only significant Fe XII Doppler shift in the entire data set is seen in these spectra where a blue shift of 9 km s$^-$1 is seen in the region between the two legs of the large C IV loop at the position of one of the fiducial wires. Otherwise, the Fe XII profiles show only smooth variations of intensity and Doppler shifts below the 3 km s$^-$1 level. The dominant feature in the Fe II and Si III spectra is in the region where the slit appears to cross several flux bundles, just to the left of the right fiducial wire. These show the velocity increase from rest to a redshift of 25 km s$^-$1 in Fe II and 17 km s$^-$1 in Si III. This velocity pattern is consistent with the twisting of these flux bundles, an impression that is strengthened by the appearance of these loops in the C IV spectroheliogram. Just to the right of the right fiducial wire, blue shifts in the opposite leg of one of these flux tubes of 16 km s$^-$1 are seen. These velocities are somewhat less than those seen at lower altitudes.

A time series of ultraviolet spectroheliograms is shown in Figure 2. Each frame indicates the elapsed time in seconds from the first exposure. Four moving or changing features have been indicated by arrows in the images. The brightest feature in the center of each frame is a surge which must have commenced just before the rocket was launched. Material at the tip of the surge is moving along its axis at a velocity of 70 km s$^-$1. The legs of the surge are rather straight and parallel to each other. The main action is at the tip of the surge which moves rapidly and in the last image seems to be breaking up into several fragments.

3. Conclusions

The HRTS-8 observations of NOAA 7260 at the limb show that the transition region and chromospheric plasmas are in a highly dynamic state. At the time of the flight, a surge was in progress. Other material motions observed included a jet, a knot and possible field line twisting. The observed activity was present well above the photosphere. The activity occurred in spite of the fact that flaring activity was unimpressive for the day as a whole and is probably typical of non-flaring transition region and chromospheric plasmas above a large, magnetically complex active region. The near-UV spectra showed dramatic differences between the appearance of the cooler lines (Fe II and Si III) and the coronal line (Fe XII). Considerable fine structure at the arc-second resolution of the instrument and large Doppler shifts on the order of tens of km s^{-1} are quite evident in the spectra of the cooler lines. In the coronal line (Fe XII), there is no strong indication of fine scale features; the Doppler velocities are mostly below 3 km s$^-$1 the limit of detectability.

The SXT observations obtained immediately before and after the flight show a set of large diffuse, coronal loops just south of the surge structure. The UV spectra obtained in this vicinity show an enhancement of the coronal line intensities. The loop structures observed with the Yohkoh SXT has only minimal correspondence with the C IV spectroheliograms. Several hours after the flight, a number of hot loops suddenly appeared in the soft x-ray images in the location of the cooler plasmas imaged earlier by the HRTS spectroheliograph to the north of the central surge. Further study of the available data may yield information on heating mechanisms of coronal plasmas.

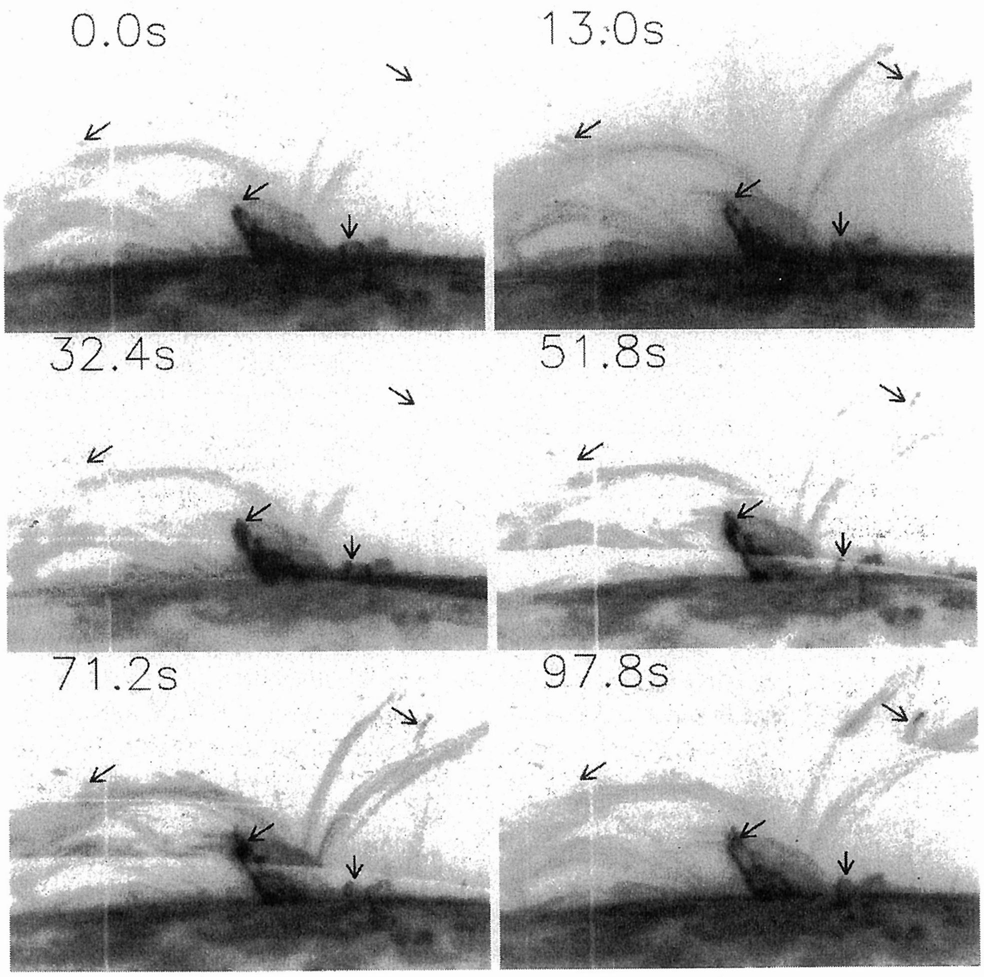

Fig. 2. A time series of the central area of the C IV spectroheliograms. Arrows indicate especially dynamic structures, including a surge, a jet, a small knot and a loop. Each frame is labeled with the elapsed time in seconds from the first exposure.

References

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