ROCKET OBSERVATION OF THE EUV IMAGES OF A SOLAR FLARE AND ACTIVE REGIONS

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Abstract. Images of a flare and active regions were obtained in the extreme ultraviolet emission lines such as C III 977 Å, Ne VIII 770 Å, and H I β, and hydrogen Lyman continua with a spatial resolution of less than ten seconds of arc together with one-dimensional scanning at 1650 Å. A microchannel plate was used as a detector, and pointing accuracy was, for about half of the observation time, around 0.5 arc sec.

The relationship between the shape of the flare and the structure of the photospheric magnetic field is discussed. A map of the electron temperature distribution derived from the intensity ratio of the Lyman continua at 880 Å and 815 Å showed a lower temperature in regions of higher activity. A very small geometrical thickness of 50–500 m in the C III emitting region of the flare was found. And the layer emitting the continuum in 1650 Å is shown to be at a temperature of 5300 K in the flare and 4700 K in active regions.

1. Introduction

We present EUV observation of a solar flare and active regions by a Japanese sounding rocket (S 520–5CN). The instrument consists of a Cassegrain telescope and a stigmatic spectrograph, where a microchannel plate (MCP) and a photomultiplier were used as focal plane detectors. During 10 min flight, decay phase of a flare (optical class 1B and X-ray class C3) was observed. EUV images of this flare and active regions were obtained in C III 977 Å, Ne VIII 770 Å, H I β lines, and H I Lyman continua at 880 Å and 815 Å, etc. together with one-dimensional scan at 1650 Å. While EUV pictures of some flares have previously been reported from the Skylab, much can be learned by studying various types of flares (see a review by Moore et al., 1980). Though the resolution was not as good as the film, technically it has been demonstrated that the MCP we used is very useful in this wavelength region. And the fine pointing control system we developed, attaining at a 0.5" accuracy, can be used for further experiments.

In this paper descriptions and observations are given in Section 2, and the results from one-dimensional scan at 1650 Å and from the EUV images are presented in Sections 3 and 4, respectively. In Section 4, we discuss, briefly, on a map of electron temperature distribution and on the geometrical thickness of EUV emitting plasmas.

2. Instrument and Observation

(a) Optics (Figure 1 and Table I): The telescope is a classical Cassegrain of an aperture of 10 cm (F/15). The secondary mirror is supported on a zimbal structure which enables fine pointing and raster scanning. The 50 cm stigmatic spectrograph makes spectral foci
TABLE I
Specifications of the instrument

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<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
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<tr>
<td>Telescope:</td>
<td>10 cm aperture classical Cassegrain. Focal length: 1.5 m. Back focus: 10 cm. Magnification: 4.6. 1° = 7.3 μm. Substrate: Zerodur. Gold-coated. λ/4 at 0.5 μm. Effective collecting area: 66 cm² (40 mm light shading circular plate on the secondary mirror). Zimbal support at the secondary mirror.</td>
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<td>Spectrograph:</td>
<td>50 cm length stigmatic spectrograph. Concave grating: 1200 gr mm⁻¹, 700 Å blaze, Pt-coated, and R = 498.1 mm. Incident angle: 10.5°. Distance between the entrance slit and grating: 489.8 mm. Central wavelength: 860 Å (MCP). Reciprocal dispersion: 16 Å mm⁻¹. Entrance slit: 30 μm × 30 mm.</td>
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<td>MCP:</td>
<td>Two-dimensional. Tandem and ion-feedback free (+ 10.3° tilted micro-channels to the main light beam). High voltage: 2100 V. 26 mm (Hamamatsu Photonix Co.). Resistive anode: 1.4 x 1.4 inch (Surface Science Eng. Co.). Maximum count: 4 x 10⁴ cps. Local saturation level: 200 cps/pixel.</td>
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<tr>
<td>Photomultiplier:</td>
<td>Hamamatsu Photonix R1081. Effective wavelength: 1150-2000 Å.</td>
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<td>Miscellaneous:</td>
<td>Weight of the instrument: 46.5 kg. Electric power: 25 W. Telemetry rate: 54.4 kbps.</td>
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<td>Resolution:</td>
<td>Spatial: nominal: 5.5&quot; (raster direction) × 5.2&quot;; effective (incl. photon count number): 10&quot; × 10&quot;. Temporal: 1 s (one picture: 100 s). Spectral: 4 Å (line) and 16 Å (continuum).</td>
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(horizontal foci) on a group of slits on the Rowland circle and after selecting emission lines and hydrogen Lyman continua it makes spatial foci (vertical foci) on a micro-channel plate and a photomultiplier (16 Å mm⁻¹). The effective width of the entrance slit on a 45° tilted mirror is 30 μm.

Lines selected on the exit slits are Na IX 680.7 Å, Ne VII 769.6 Å, C III 976.6 Å, Si XII 499.5 Å (2nd order), H I Lβ 1025.4 Å, and O VI 1031.7 Å with a slit width of 4 Å and with a slight tilt of 2.1° as shown in Figure 1. This tilt will give a larger tolerance for the relative positioning of slits and emission lines against possible dislocation by shocks at the time of rocket firing. Note that O VI 1031.7 Å is recorded in the same channel as H I Lβ. Slit length for Si XII 499.5 Å is set short because it was feared to be contaminated from neighboring Lβ and C III. Hydrogen Lyman continua are selected at 732.8 Å, 815.0 Å, and 880.0 Å without tilt because of wide slits of a 16 Å width.

Spatial resolution of the present observation is largely limited by the resolution of the detector (≤7° = 50 μm), and partly by defocusing and tilting of the secondary mirror (≤2°). And the overall resolution of ≈10" seems to have been attained in the active region where enough photon counts were received.

(b) Detectors: The main detector is tandem microchannel plates of resistive anode type (MCP, see Table I for specification). The resistive anode counts the number of photons coming in each of 256 pixels in the direction of slit length (5.2° each on the Sun) and in each of 8 channels in different wavelengths. Eighty-four pixels out of 256 were cut off from the Sun's light to see scattered light and noise. Quantum efficiency of the MCP, and reflectivity of a gold-coated mirror and of a platinum-coated concave