BALLOON OBSERVATION OF THE F-CORONA AT THE 1983 TOTAL SOLAR ECLIPSE

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ABSTRACT. A balloon observation of the F-corona in visual and infrared regions was carried out by Japanese and Indonesian teams at the total solar eclipse on June 11, 1983, in Java, Indonesia. For the visual observation, a SIT television camera, with 4 interference filters (5300Å, 6000Å, 7200Å and 8000Å) and a 45°-step rotating polarizer, was used. The camera measured brightness distributions in a sky area of 5°×5° centered at the eclipsed sun at each polarizer position for each filter. In this paper, a part of results, which are the brightness and polarization distributions in a half area of the 6000Å picture, is shown.

1. INTRODUCTION

At the total solar eclipse on June 11, 1983, in Indonesia, we have made a photo-polarimetry of the F-corona in both visual and infrared regions by using a balloon under a cooperation between Japanese and Indonesian teams. Our main purpose was to find precise position of the boundary of the dust free zone, where the interplanetary dust approaching to the sun sublimates due to temperature increase.

The use of a balloon is not only needed for infrared measurement in order to avoid strong absorption by the lower atmosphere, but also much advantageous for visual observation in reducing the background sky brightness as shown in Fig. 1 (from Saito (1959)).

This paper is a report on the circumstances of our balloon observation and result of the visual region measurement reduced from a part of data until the present.

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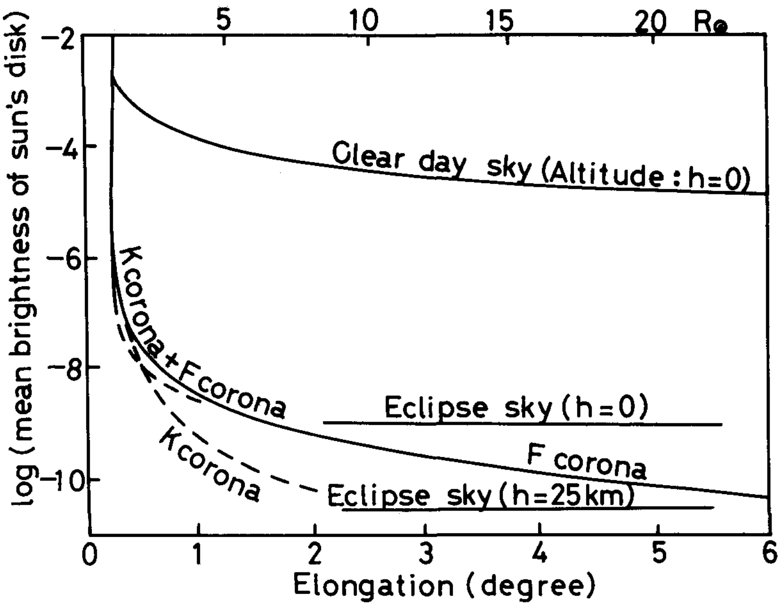

Figure 1. Brightness of the corona and sky (from Saito (1959)).

2. PREPARATORY PHASE

Detailed prediction and explanation of the total solar eclipse on June 11, 1983 had been given by Fiala and Lukac (1982).

In 1980 the Japanese team began to study the feasibility of a balloon observation at the eclipse in Indonesia, and the Japan-Indonesia cooperative plan started in 1981.

The balloon and payloads; photometers, telemeter, attitude control and remote control systems, had been prepared in Japan. Performance test of these instruments was made by a balloon flight in Japan in September 1982.

In Indonesia, a new balloon launching base was constructed at Watukosek, East Java by the Indonesian National Institute of Aeronautics and Space. Ground equipments; launcher, gas injection system, receiving and transmitting system, have been provided.

In the tropics, usually, the stratospheric wind direction alternates between easterly and westerly with a period of 26 months (see Labitzke, 1982), and a prediction (Yamanaka, (1983)) showed that June 1983 would be just in its reversal period. However, from our small rubber balloon flights made during three weeks prior to the eclipse day, we found that the wind direction is favorable (easterly) for our eclipse observation.

3. INSTRUMENTS

A. SIT (Silicon Intensifier Target) television camera was used for the visual region observation. In front of the objective lens (50mm aperture, F/2), a shutter, a filter-wheel and a 45°-step rotating polarizer are installed. The camera takes pictures, one consists of 256×256 pixels, of the brightness distribution in a sky area of 5°×5° centered at the eclipsed sun at each polarizer position (1.8 sec/position) with exchanging four interference filters of 5300Å, 6000Å, 7200Å and 8000Å (15 sec/filter). To eliminate the effect from the bright inner corona, the camera has an occulting disk at its direct focus, which is a sputtered metal on a thin optical glass inclined at 45° to the optical axis. The radius of the occulting disk corresponds to $3.5R_{\odot}$ ($R_{\odot}$: sun's radius).

Both infrared and visual photometers were set on a same platform in a gondola. The elevation angle of the platform can be changed by remote control while watching a monitor-display at Watukosek Base. By an attitude control system developed by Nishimura et al. (1984), the direction of the gondola can be kept to the sun's azimuth, which changes gradually, with referring to the direction of geomagnetic line of force.

All the data were recorded in a video tape-recorder on board, and a part of them was transmitted to Watukosek Base through the telemeter.

4. OBSERVATION

The balloon of 15,000m^3 with payload of 150kg was launched at 0713 LT on June 11. Fig. 2 is its construction. The balloon reached the level altitude of 30.8km at 0837 LT, then drifted to west-south-west direction with a speed of 80km/h. The trajectory is shown in Fig. 3. The SIT camera was used for monitoring the sun during the partial phase of the eclipse through a small iris and a density filter.

The balloon encountered shadow of the moon at 1128 LT at 30.5km height over a position of about 40km east-south-east from Jogjakarta. Duration of totality at the balloon was 3^m50^s. Immediately after the 2nd contact, observation was started by remote control. The instruments worked properly throughout the totality under attitude control within ±8 arc seconds.

After the observation, the payload was recovered safely by a parachute.

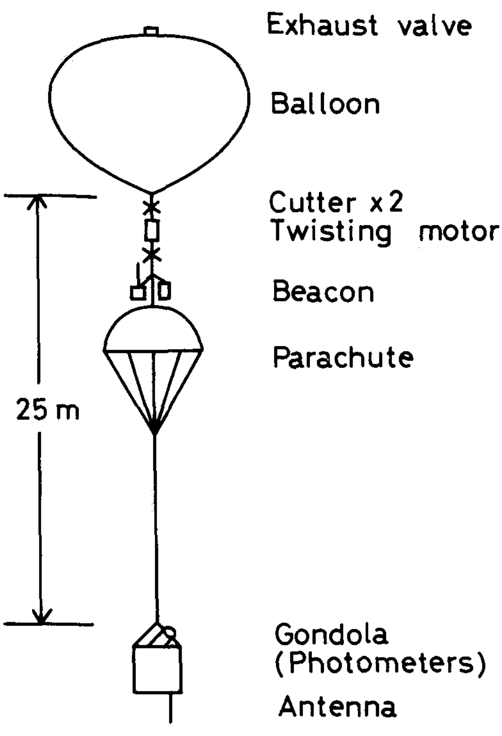

Figure 2. Construction of the Balloon.

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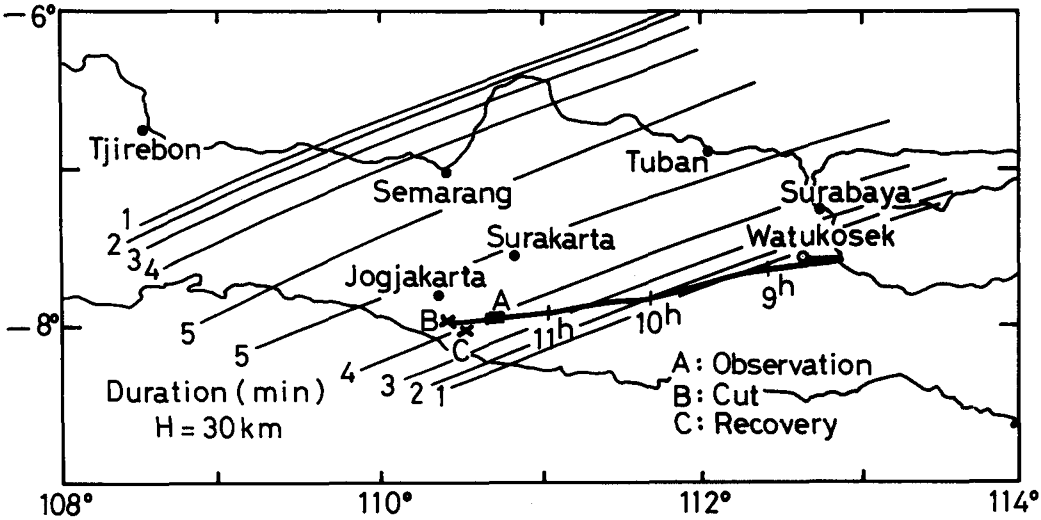

Figure 3. Trajectory of the balloon, June 11, 1983.
Durations of the totality in the eclipse zone are indicated.

5. METHOD OF REDUCTION

Before full reduction of all the data using a computer, we took several tens sample points in a picture, and analyzed their data with careful check and necessary corrections at the following each process. (1) Inter-calibration among sensitivities of the pixels was made by using data of picture of a uniformly illuminated surface. (2) From Fig. 1 and from the discussion by Blackwell et al. (1967), we assumed that the background sky brightness at 30.5km is negligible compared to the F-corona brightness inside of our 5°×5° picture. (3) Polarization effect by the 45° glass plate (occulting disk) set at the direct focus was measured in the laboratory. The ratio k, of the transmitted intensities of linearly polarized light, of which electric vectors are parallel; $I_{\parallel}$, and perpendicular; $I_{\perp}$, to the plane of incidence, is $k = I_{\perp} / I_{\parallel} = 0.827$. (4) The Stokes parameters; I,Q,U,V, at each sample point were obtained with the least-squares method using equations;

$$\begin{aligned} 2kI + 2kQ &= I(0^\circ) \\ (1+k)I + (1+k)\cdot\tan2\chi\cdot Q &= I(45^\circ) \\ 2I - 2Q &= I(90^\circ) \\ (1+k)I - (1+k)\cdot\tan2\chi\cdot Q &= I(135^\circ), \end{aligned} \qquad (1)$$

where $I(\theta)$ is the observed intensity at polarizer position θ. We assumed here that V=0, and position angle χ, of the F-corona polarization is perpendicular to the radial vector from the sun, which gives relation of $U=Q\cdot\tan2\chi$. (5) Relative brightness; B, of each sample point was obtained from $B=\Sigma I(\theta)$, $\theta=0°, 45°, 90°, 135°$. (6) We did not separate the K-corona component, which is usually small (<1/10) compared to the F-corona component outside of $5R_\odot$.

6. RESULTS

We show here our results only for the left half area of the 6000Å picture, which have been obtained until the present time.

Fig. 4 is an isophote map of the relative brightness. Contour lines were drawn with log B, and B was expressed in an arbitrary scale. Since the data within $5R_{\odot}$ from the sun showed a gradual saturation, we plotted only the brightness outside of $5R_{\odot}$. The contours in Fig. 4 are concentric circles slightly elongated toward the ecliptic. However, we can not determine the precise direction of the axis of elongation only from this map.

The slope of the brightness decrease with increase of the heliocentric distance in the equatorial region

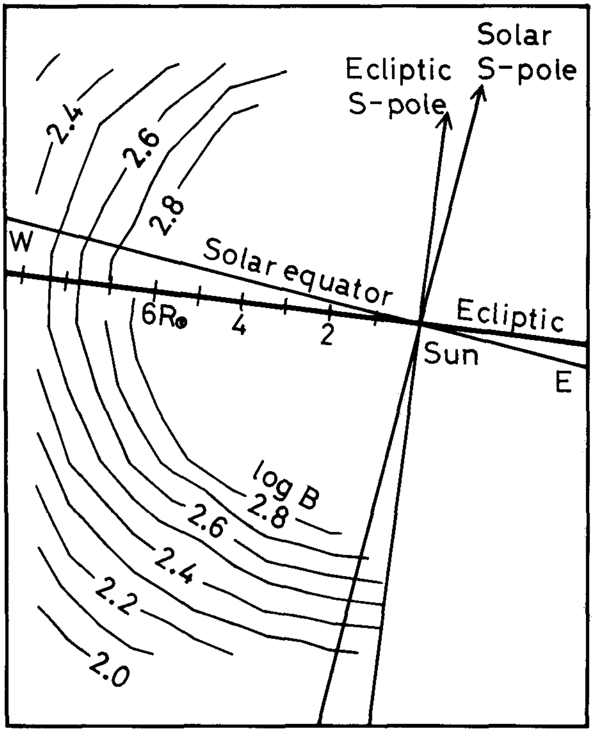

Figure 4. 6000Å relative brightness distribution of the F+K corona.

TABLE 1. Positions, Heliocentric distances ($R/R_{\odot}$) and Polarization degrees (p, in per cent) of the Sample Points.

$\lambda-\lambda_{\odot}$	β	$R/R_{\odot}$	p	$\lambda-\lambda_{\odot}$	β	$R/R_{\odot}$	p
0°.65	2°.08	8.27	9	1°.89	-1°.30	8.73	16
0.70	1.69	6.95	4	1.62	2.21	10.40	6
0.75	1.30	5.72	6	1.67	1.82	9.38	9
1.11	-1.41	6.83	18	1.72	1.43	8.51	8
1.31	-1.38	7.23	9	1.77	1.05	7.82	6
1.04	2.13	9.00	9	2.08	-1.28	9.29	17
1.09	1.74	7.81	6	2.22	-0.86	9.07	19
1.14	1.35	6.73	5	2.28	-1.25	9.88	16
1.19	0.97	5.83	10	2.00	2.26	11.48	12
1.50	-1.36	7.69	11	2.03	2.07	11.01	14
1.38	0.99	6.48	11	2.06	1.87	10.57	10
1.42	2.18	9.90	15	2.11	1.48	9.80	14
1.47	1.79	8.83	4	2.16	1.10	9.21	11
1.53	1.41	7.89	5	2.47	-1.23	10.48	20
1.58	1.02	7.14	11	2.50	-1.42	10.92	16
1.63	0.63	6.65	9				

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agrees in general with those of the previous observers, particularly with that of Saito and Hata (1964) observed in an approximately same phase of the solar cycle.

The positions and polarization degrees of the sample points are listed in Table 1, and shown in Fig. 5. Probable errors of the polarization degree estimated from the least squares calculation of equations (1) are within ±3 per cents. Because the data of the points in the ecliptic and polar regions include noise slightly large for polarization calculation, they are not shown here.

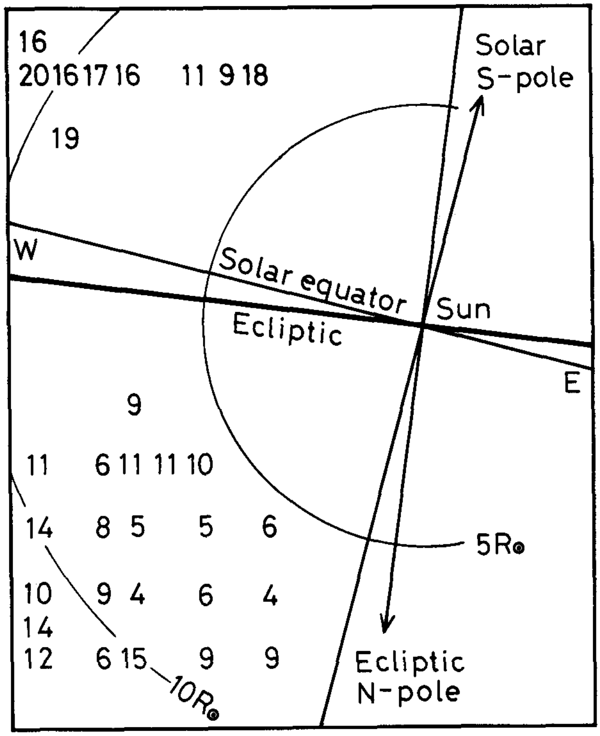

Figure 5. 6000Å polarization of the F+K corona (in per cent).

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