RESEARCH ON THE SUN, EARTH, AND MOON AT THE TOTAL SOLAR ECLIPSE IN INDONESIA ON 11 JUNE 1983

「昭和58年6月11日インドネシア皆既日食による太陽・地球・月の研究」

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海外学術調査　研究成果報告書

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研究代表者　日江井　栄二郎

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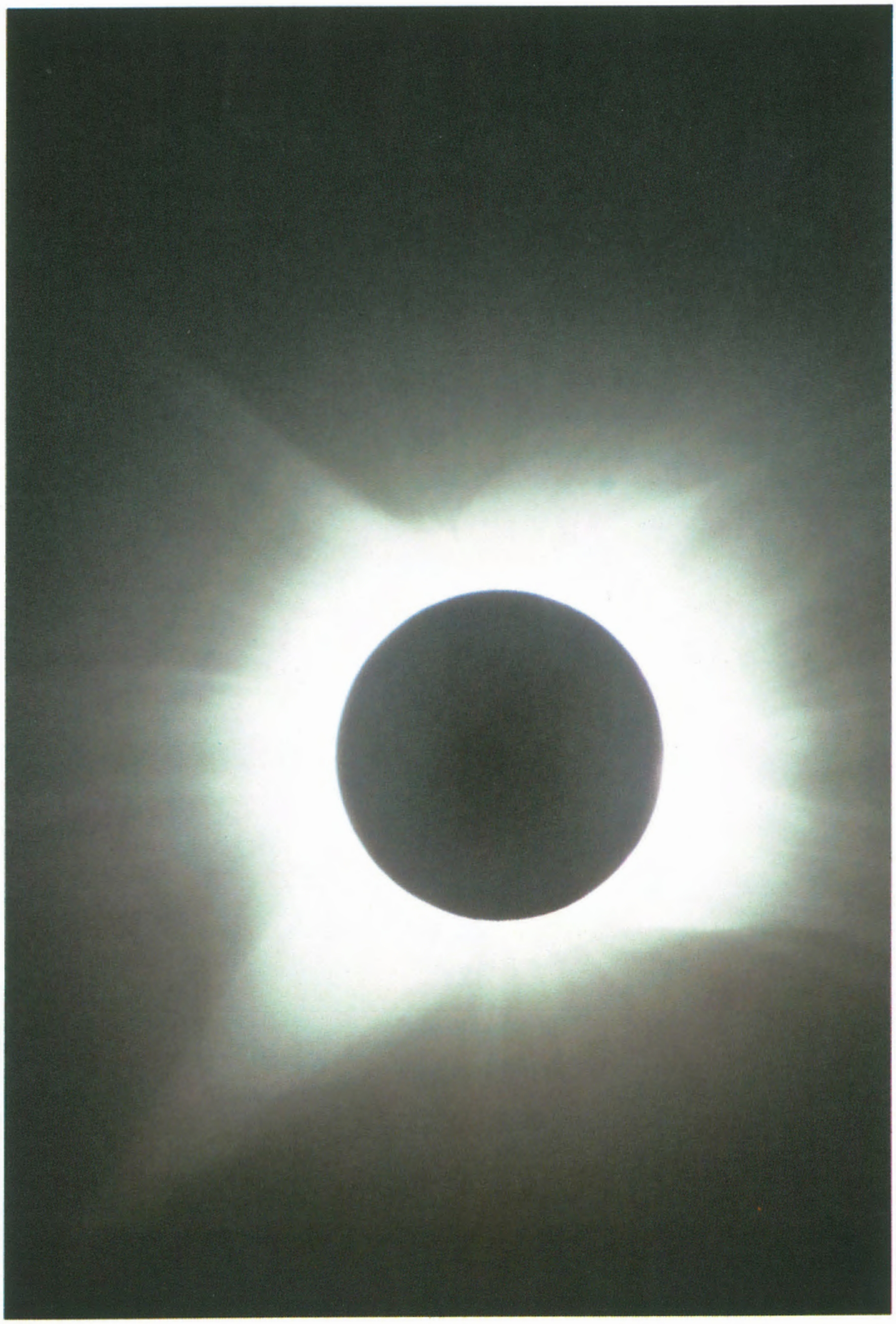
E  W

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RESEARCH ON THE SUN, EARTH, AND MOON AT THE TOTAL SOLAR ECLIPSE IN INDONESIA ON 11 JUNE 1983

「昭和５８年６月１１日インドネシア皆既日食による太陽・地球・月の研究」

昭和６０年３月

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海外学術調査　研究成果報告書

（５９０４３０１８）

研究代表者　　日江井　栄二郎

「昭和５８年６月１１日インドネシア皆既日食による太陽・地球・月の研究」

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Research on the Sun, Earth, and Moon at the Total Solar Eclipse in Indonesia on 11 June 1983

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PREFACE

Human beings have been seeing the solar corona with feelings of unrest, awe, and glory, through the past. The phenomenon of a total solar eclipse can fortunately be seen because the angular sizes of the Sun and the Moon happen to be about the same. When the Moon's angular size becomes larger than the Sun's, a total eclipse takes place and the beautiful solar corona can be seen. If the size of the Moon was much smaller, the discovery of the existence of the corona in the Sun and stars would have been made much later.

A total eclipse of the Sun is a good opportunity for observing the corona, the transition region between the corona and chromosphere, and the chromosphere, that are too faint to be observed otherwise. Interplanetary dust surrounding the Sun, seen as the F corona, is also an important object that one has a chance to observe during an eclipse. From the observation at the second and third contact, the relative position of the Sun and the Moon can accurately be determined. The ionosphere of the earth changes in response to the cut-off of ultra-violet radiation from the Sun, and the geomagnetic phenomena in the atmosphere affected by such an eclipse also occurs. The observation at a pair of geomagnetic conjugate stations, which are in and onside zone of the totality, is interesting. The total eclipse of the Sun is naturally not the only method to investigate phenomena related to the following subjects, but it provides unique and valuable data concerning solar physics, interplanetary and solar system physics, astrometry, relativity, and geophysics.

The total solar eclipse on 11 June 1983 in Indonesia was a major event from both the astronomical and geographical points of view: the duration of the totality was as long as 5 min., the eclipse could be observed at a high altitude (near noon), and furthermore, the time of the eclipse was during a dry season, and the transportation of the observation equipment was not difficult to accomplish.

Seven institutes in Japan (Tokyo Astronomical Observatory, Kyoto University, Tohoku University , Tohoku Institute of Technology, International Latitude Observatory, The Institute of Space and Astronautical Science, and Hydrographic Department of Japan) performed researches on the Sun, Moon, and Earth during the eclipse, mainly supported by a Grant in Aid for Overseas Scientific Research of the Ministry of Education, Science, and Culture, Japan.

In this report, the purpose of observations of total solar eclipses, circumstances of the eclipse on 11 June 1983, the preparation, cooperation involved and the schedule for the observation are described in Section I. The purpose of the observation of the Indonesian eclipse, its plan, observation equipment used, observation procedure, data acquisition data reduction, and analysis of each institution are reported in Section II.

In carrying our project into execution, we have had many support, invaluable help, kind encouragement, and useful suggestions. We would like to express our hearty thanks to the following organizations;

- Overseas Scientific Research of the Ministry of Education, Science and Culture, Japan,
- Special Project Research of the Ministry of Education, Science and Culture, Japan,
- The Ministry of Foreign Affairs, (Second Cultural Affairs Division, Public Information and Cultural Affairs Bureau), Japan,
  for a grant in aid of research in Indonesia and Taiwan, and of preparation for observation equipment, and for negotiating with the Government of Republic of Indonesia,

- National Committee for Solar Eclipse, Science Council of Japan,
  for discussing the assessments of the purposes and the metod of the observations in the Indonesian eclipse, and for organizing the eclipse team,

- Working Group on Solar Eclipse, Commission 12 of

International Astronomical Union,
for providing information concerning the decision made by the IAU,

- Ambassy of Japan in Indonesia,
- Consulate-General of Japan in Surabaya,
for sending information concerning the eclipse and local conditions in Indonesia, and negotiating with the customs authorities for a clearance and a settlement of a problem of the equipment,

- Embassy of the Republic of Indonesia in Tokyo,
for giving information on Indonesia and issue offical visas,

- National Committee for 1983 Solar Eclipse (LIPI: Indonesian Institute of Sciences),
- LAPAN (Indonesian National Institute of Aeronautics and Space),
- Bosscha Observatory,
- UNESCO in Jakarta,
- the National Central Unversity in Taiwan,
for providing information relating to the eclipse and special custom procedures for the equipment, looking for observing sites, sending staff members of LAPAN to each observing sites, and carrying out cooperative observation with a balloon, and providing all the necessary assistance,

- University of Tokyo (Academic Affairs Division and Budget Division),
for making every effort to produce fruitful results of the eclipse observation,

- Marubeni Corporation, and Ajinomoto Co., Inc,
for quickly providing necessary and accurate information concerning the eclipse, and for extending invaluable and great help.

March 1985

Eijiro HIEI

CONTENTS

PURPOSE OF OBSERVATIONS OF TOTAL SOLAR ECLIPSES

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The solar corona can be observed in detail from the ground during an occasion of a total solar eclipse. The spectrum of the corona is composed of continuum, emission lines, and Fraunhofer absorption lines. The corona seen in continuous spectrum, emission lines, or Fraunhofer lines is called the K corona (Kontinuierlich), the E corona (Emission), or the F corona (Fraunhofer), respectively. The E corona, seen in 5303A and 6374A lines, or the K corona at a height as low as 0.05 solar radii from the solar limb can be observed with a coronagraph, which provides data for the time variation of the E corona and the K corona near the photosphere. The corona can also be observed with x-ray radiation from a satellite, but its spatial resolution is about 2-3 arc sec. Although the duration of a total solar eclipse is as short as several min., data of the E corona, the K corona and the F corona obtained during the eclipses can supply valuable information on the physical properties of the corona.

The corona surrounding the photosphere is at a much higher temperature than the supposed heat source; the temperature of the corona is about $(1\sim2)\times10^6$K while that of the photosphere is about 6000K. Elucidating the heating mechanism of the corona is one of the important problems in Astrophysics. Heating by sound waves originating from the solar convection zone was the prevailing theory, but it turns out to be improbable now. There are no observations showing the evidence of the sound waves through the chromosphere into the corona in EUV lines, and almost all stars have stellar coronae, which can not be explained by the theory of coronal heating derived from the study the solar corona.

There is no standard theory of the coronal heating now, but the proposed heating mechanisms are grouped into two categories; wave heating and current heating. The former theory of wave heating assumes that some type of magneto-hydrodynamic wave propagates through the upper atmosphere, damping part of its energy in the corona, and the latter assumes heating through ohmic dissipation due to the electrical currents in the corona.

The other important information from the corona is that it is inherently structured. The solar corona has been modeled as a homogeneous medium for a long time, reflecting somehow the observational averaging due to the finite instrumental resolution. The structuring present in the corona is so diverse that it seems reasonable to consider it as a collection of different structures, whose properties should be studied separately.

Solar wind, reaching the earth in 2-4 days after its departure from a region above the coronal hole, demonstrates that in the corona, there are sources of energy and momentum other than heating and radiation pressure that accelerate the wind. Observational evidence of the wind and its acceleration is needed.

Line shifts and profiles of coronal emission give information on the velocity field and kinetic temperature in the corona; an outflow velocity in a streamer related to the solar wind, a small velocity near a fine structure which is presumably related to magnetic field, coronal wave motion, and the kinetic temperature above an active region or a normal region. Linear polarization of emission lines gives data on the magnetic field in the corona in the plane of the sky. Observation of K corona is useful for an estimation of electron density in a fine structure and for detecting brightness changes in a loop probably due to wave motion.

The interplanetary dust surrounding the sun can be observed as the F corona at a total solar eclipse. Its intensity is so faint that it is desirable to observe it from high altitude i.e., from an airplane or a balloon, because background sky brightness caused by atmospheric scattered light coming from outside the zone of totality becomes weaker as the altitude increases.

The circum-solar dust is thought to be spiraling and falling toward the Sun because of deceleration due to the solar radiation pressure (the Poynting-Robertson effect). The dust material is sublimated at a distance around 4 solar radii by the solar radiation. The visible and infra-red observations of the F corona is important for studying the physical characteristics of the dust material.

An apparent motion of the Sun relative to the Moon is about 200km/sec, which means that the eclipse observations can be carried out with a very high spatial resolution when the observation is made within a short interval. If the eclipse is observed at a rate of 1 sec., like a "jumping film" method, the information of the outer layer of the Sun is obtained with a spatial resolution of 200km, which is 5 times better in comparison with a usual solar observation made with a spatial resolution of about 1000km. Therefore the eclipse is a good opportunity for the observations of the extreme limb of the photosphere, the chromosphere, and the transition layer between the chromosphere and the corona.

Flash spectra of the chromosphere above normal and active regions, taken with a high time resolution, give a lot of information on the physical condition of the chromosphere. The accurate determination of the position of the solar limb can also be made at the total solar eclipse, which provides useful data for an astrometric study.

At a solar eclipse, the shadow of the moon moves across the earth from west to east, and the ionosphere and the upper atmosphere of the earth are locally affected by it and phenomena that occur are observed. The eclipse is therefore an opportunity for studying geophysical phenomena related to the ionosphere or for photochemistry of the upper atmosphere.

The solar corona can be observed not only at the event of the total eclipse of the Sun, but with a coronagraph, x-ray telescopes onboard a satellite, or radio telescopes. Radio observation is useful for studying the corona and the chromosphere with high time resolution, but its spatial resolution, in general, is low. The coronal observation made during the eclipse is nowadays superior as far as the spatial resolution and the accuracy of photometry are concerned. The total eclipse of the Sun is, therefore, not the only way to investigate the corona, but it povides important data for studing the physical state of the corona.

According to Einstein's theory of general relativity, the maximum deflection for a star just grazing the Sun would the 1.75 arc sec., and the deflection angle should descrease in inverse proportion to the angular distance of the star from the center of the Sun. The observations of the deflections performd during eclipses seem to have confirmed general relativity, but the result was not accurate enough to distinguish between the Einstein theory and the Brans-Dicke theory. Furthermore the deflection angle derived from the observed data until now, seems to be correlated with a solar activity.

The observations carried out during the total eclipse of the Sun provide important and useful data related to solar physics, interplanetary physics, solar system physics, general relativity, astrometry, and geophysics.

CIRCUMSTANCES OF TOTAL SOLAR ECLIPSE OF 1983 JUNE 11

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Hydrographic Department of Japan

A total solar eclipse passing through Indonesia and New Guinea occurred on June 11, 1983. The circumstances of this eclipse, especially focused on those in Jawa and Sulawesi islands of Indonesia, are presented.

1. GENERAL SITUATIONS

A total solar eclipse, which has the Oppolzer number 7597, occurred on June 11, 1983. One Saros has elapsed since the eclipse that occurred in southern pacific on May 30, 1965. This time the path of total phase moved approximately 120° westward and 5° southward. The situation is shown in Figure 1. The eclipse began in the southern part of the Indian ocean, landed on Indonesia passing through Jawa and Sulawesi islands, went to New Guinea and ended in the Coral sea. In Japan, a small partial eclipse was seen at Nansei Syoto. The central eclipse began at 3^h11^m UT at 60°.2E, 36°.2S. The central eclipse at local apparent noon occurred at $4^h33^m25^s$ UT in Jawa island at 111°.5E 7°.2S and the duration of totality was 5^m08^s. The central eclipse ended at 6^h14^m UT at near New Hebrides islands at 168°.3E, 18°.1S. The maximum duration of totality occurred at 4^h47^m UT around 115°.3E, 5°.9S with 5^m11^s of duration.

2. CIRCUMSTANCES OF THE ECLIPSE IN INDONESIA

The circumstances of the eclipse in Jawa and Sulawesi islands are presented in Table 1 and Figures 2-4. Figure 2 shows the time of maximum totality. Figures 3 and 4 give the time and postion angle of the second (beginning of totality) and third (end of totality) contacts, respectively. The precision of reading the figures will be 1^s in time and 1° in position angle. The position angle is defined to be the angle measured counterclockwise from the north to the direction of contact point seen from the center of the sun.

The computations to make these results are based on the IAU (1964) system of astronomical constants. As for the moon's radius measured in the Earth's radius, 0.2722810 is used and a correction of −0".6, that is the difference between the center of the shape and the center of gravity, is added to the latitude of the moon. Therefore the profile of lunar limb is taken into account in an averaged sense. The correction of time $\Delta T(=ET-UT)$ is assumed to

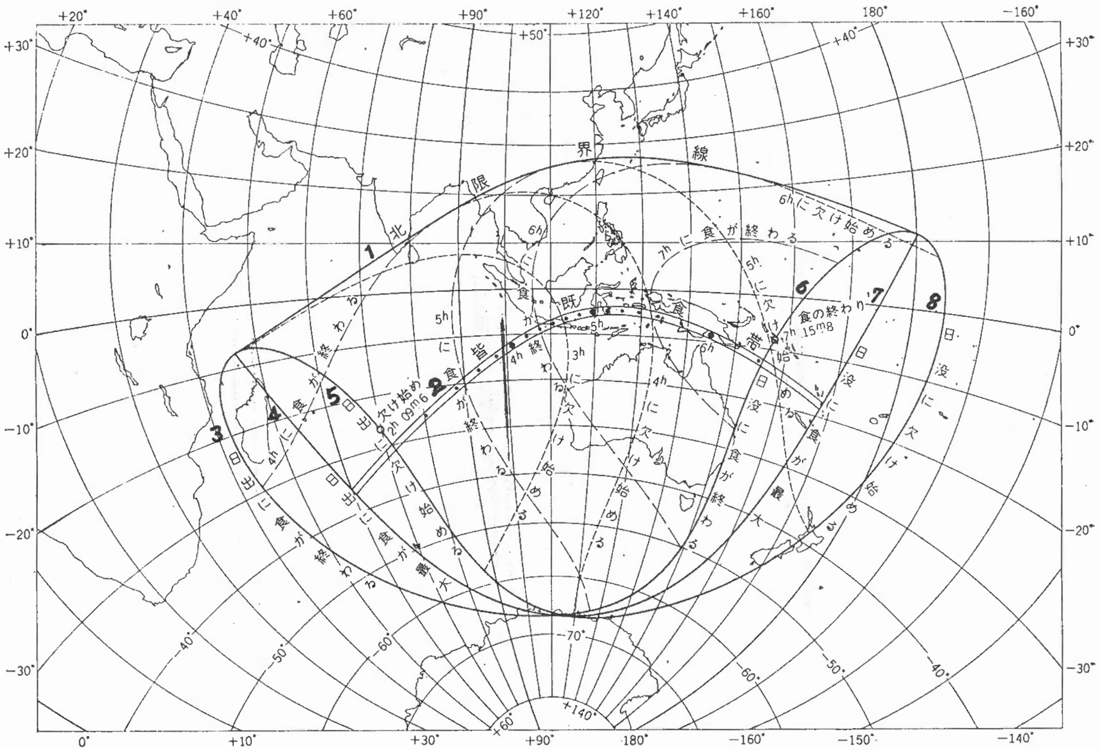

Figure 1 Map of total solar eclipse on June 11, 1983

1 Northern Limit of Penumbra
2 Path of Umbra
3 Eclipse ends at Sunrise
4 Maximum eclipse at Sunrise
5 Eclipse starts at Sunrise
6 Eclipse ends at Sunset
7 Maximum eclipse at Sunset
8 Eclipse starts at Sunset

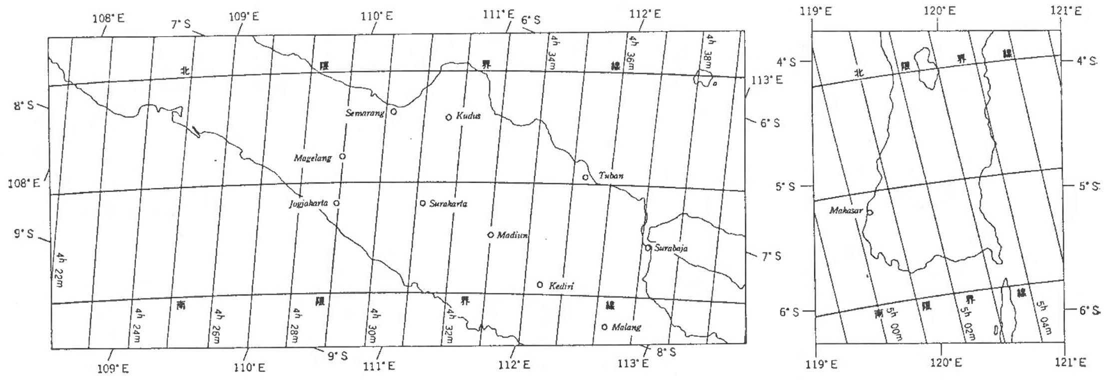

Figure 2 Time of maximum totality in UT

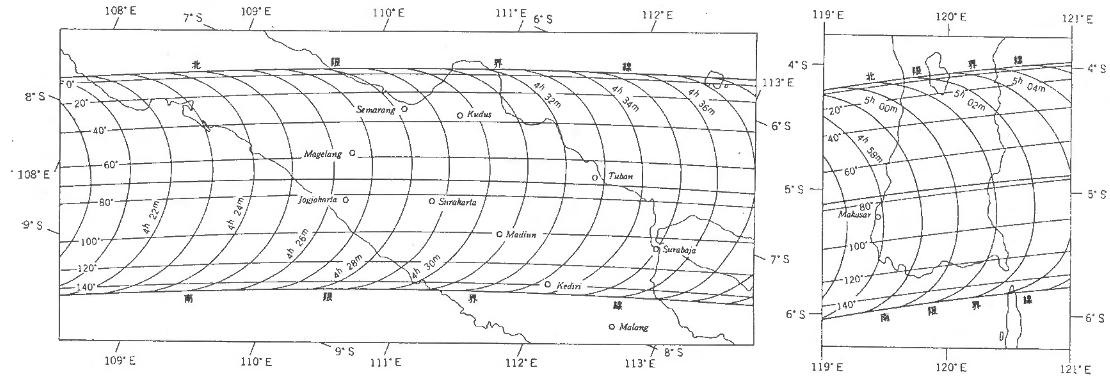

Figure 3 Time and position angle of the second contact

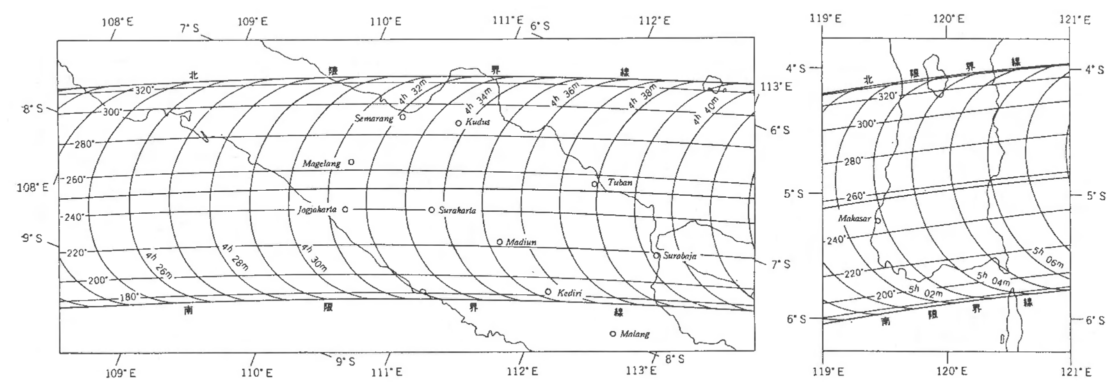

Figure 4 Time and position angle of the third contact

Table 1 Path of total phase in Indonesia

	Northern Limit		Central Line				Southern Limit	
UT	Long.	Lat.	Long.	Lat.	Duration	Alt.	Long.	Lat.
4^h24^m	108°.4869	−7°.4897	108°.7434	−8°.3335	$5^m.03$	58°.2	108°.9948	−9°.1829
26	109.0771	−7.2230	109.3322	−8.0697	5.05	58.6	109.5825	−8.9217
28	109.6646	−6.9665	109.9179	−7.8160	5.08	59.0	110.1669	−8.6707
30	110.2497	−6.7201	110.5012	−7.5724	5.10	59.3	110.7487	−8.4297
32	110.8332	−6.4837	111.0826	−7.3386	5.12	59.6	111.3284	−8.1984
34	111.4153	−6.2571	111.6626	−7.1146	5.13	59.8	111.9065	−7.9769
36	111.9968	−6.0403	112.2417	−6.9004	5.15	60.0	112.4836	−7.7650
38	112.5780	−5.8332	112.8203	−6.6957	5.16	60.2	113.0601	−7.5627
5 00	119.0887	−4.1937	119.2960	−5.0757	5.13	58.5	119.5052	−5.9609
02	119.7036	−4.1037	119.9074	−4.9867	5.11	58.1	120.1135	−5.8729
04	120.3246	−4.0241	120.5248	−4.9078	5.09	57.6	120.7277	−5.7948
06	120.9523	−3.9548	121.1488	−4.8392	5.06	57.1	121.3486	−5.7268
08	121.5871	−3.8961	121.7800	−4.7811	5.04	56.6	121.9768	−5.6690
10	122.2298	−3.8482	122.4191	−4.7335	5.01	56.0	122.6128	−5.6218
12	122.8809	−3.8114	123.0668	−4.6968	4.98	55.4	123.2574	−5.5853

Table 2 Elements of total eclipse along the central line

	First Contact	Maximum Eclipse	Fourth Contact
R.A. of Sun	$5^h14^m53^s.8 + 0^s.47$ E	$5^h15^m15^s.5 + 0^s.57$ E	$5^h15^m32^s.2 + 0^s.48$ E
Decl. of Sun	23 02'21" + 0".5 E	23 02'29" + 0".6 E	23 02'57" + 0".4 E
S.D. of Sun	945".1	945".1	945".1
S.D. of Moon	993".3 + 0".20 E	994".5	993".0 − 0".18 E
Relative motion			
Speed ("/s)	0.34−0.003E	0.32	0.35+ 0.003E
Direction	67°.2 + 0°.28 E	73°.9 + 0°.61 E	82°.3 + 0°.53 E
Altitude of Sun	55°.4 + 1°.08 E	59°.1 − 0°.10 E	47°.5 − 0°.99 E
Azimuth of Sun	29°.4 − 2°.16 E	348°.2 − 3°.31 E	315°.8 − 1°.76 E

E = East longitude − 115 (in degree)

52^s. Table 2 gives miscellaneous information. In order to use this Table the observation site must be identified in Figures 2-4. Then a perpendicular line toward the central line of totality from it should be fallen, and the longitude of the cross-point is to be found. In Table 2, E is defined as the difference in degree between the longitude (positive for east longitude) and 115°E. The values at the observation site is calculated by the linear functions of E given in the Table. The calculated values will have the precision to the same significant figures listed in the Table. But, the altitude and azimuth of the sun may have errors up to 1 in the last digit.

3. PROFILE OF LUNAR LIMB

The profile of lunar limb at this eclipse is shown in Figure 5. This Figure is derived from the Watts' charts. This profile is based on the libration of the moon at 4^h30^m UT, at 110°.5E, 7°.6S which is almost the same within these areas shown in Figures 2-4. The directions of N and L mean those of north in the sky and the north pole of the moon, respectively. The parameters of l and b are the libration of the moon and C is the position angle of the north pole of the moon(L).

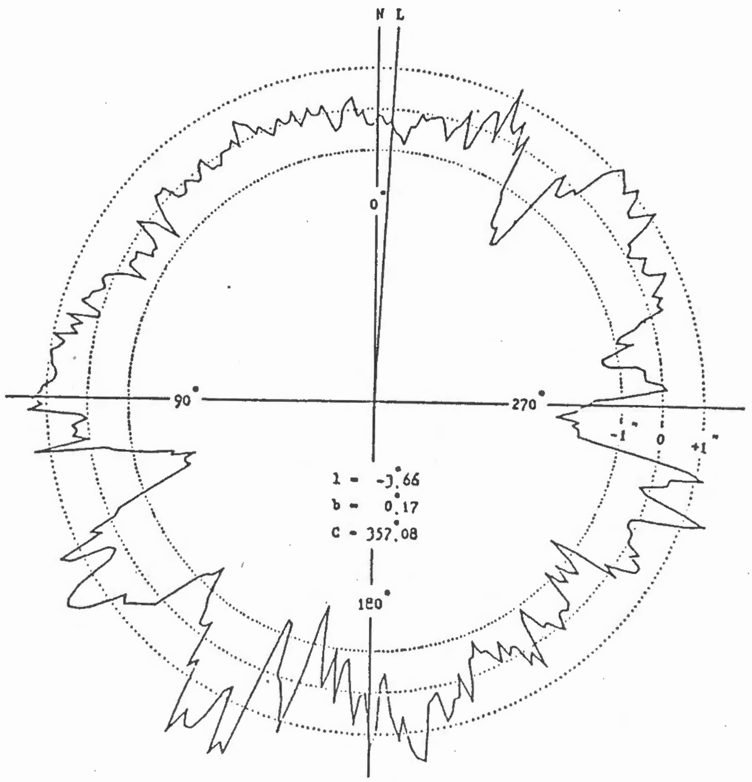

Figure 5 Lunar limb profile at the total eclipse

PREPARATION AND COOPERATION FOR THE OBSERVATION OF THE ECLIPSE

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The totality of a solar eclipse occurs at a definite time, and the telescopes and their accessaries for the observation must work well just during that short time. Observations of total eclipse of the Sun, therefore, need to be carried out under thoroughgoing preparations. One has to build, in a sense, a small observatory temporarily at a foreign place in a zone of the totality, and therefore gather a lot of information on meteorological conditions at an observing site, land appropriate for the observation, customs clearance of the equipment, its transportation to the observing site, electricity and accomodation, cooperation and support of the lacal authorities and so on.

General talk on the total solar eclipse in Indonesia was made on 13 October 1979 at the National Committee for Solar Eclipse, Science Council of Japan, and then circumstances of the eclipse, the climate in Indonesia, and the geographical situation were discussed there. It turned out that the eclipse would occur at Java island in a dry season and the duration of the totality was quite long. The meetings of the National Committee held in 1980-1983 were very useful and helpful for us in discussing the purposes of the observations, and the strategy of the project to accomplish.

The final plans of the observations at the total solar eclipse on 11 June 1983 were made in 1981 at the seven institutes (Tokyo Astronomical Observatory, Kyoto University, International Latitude Observatory, The Institute of Space and Astronautical Science, Tohoku

University, Tohoku Institute of Technology, and Hydrographic Department of Japan), and we started to set up electronics and optical parts, to build coelostat, telescopes and spectrographs, and to make concrete piers for these equipment in 1982. Fine adjustment of the telescopes was made in the fall of 1982. Photographic exposure times appropriate for taking image of the corona were determined by using the full moon, since the brightness of the corona is about the same as that of the full moon. From the end of 1982 to January 1983 we were busy with the final adjustment of the telescopes. The rehearsals of the observations were often made and we did bear the order of the observing program in both mind and body.

Fortunately our staff members made survey of several observing sites in Indonesia, and made reports on the procedures for getting permission of the observation, for visas, and for customs clearance, and on the climate, land for observation materials supplied there, electricity, water, housing, laborers, hospital, road, transportation and so on.

Embassy of Japan in Jakarta (Mr. H. Wakabayashi) informed us of the important and essential procedures which we should prepare for the Indonesian authorities in order to carry out our eclipse project.

Meteorological Agency provided data on climatic conditions in several regions in the eclipse zone, and Mr. K. Mori described "Meteorological Data in June at Surabaya, Makasar, and Port Moresby" in the Astronomical Herald (March 1981).

Marubeni Cooperation in Jakarta (Mr. Y. Mizuta) sent us accurate and up-to-date information about the situation in Indonesia.

National Committee for 1983 Solar Eclipse, Indonesian Institute of Science (LIPI) sent us general information about the Indonesian eclipse and assisted the procedures of the entry and the customs clearance of the equipment.

The Indonesan National Institute of Aeronautics and Space (LAPAN) (Dr. R. Soenaryo, Professor Wiranto Arismunandar, and Ir. J. Soegijo) had decided to make cooperation of a balloon experiment with us in order to observe the F corona, and sent LAPAN's staff members to each of our oberving team.

Bosscha Observaory (Professor B. Hidayat) also gave us invaluable advice from a point of astronomer's view.

The National Central University at Chung-Li in Taiwan is a geomagnetic conjugate station of Cepu in Indonesia, and the observations carried out at both stations during the eclipse was interesting. President C.T. Yu and professor C.A. Lin of the University afforded our Taiwan team all the necessary assistances during the eclipse observation.

REPORT ON THE PREPARATION AND OPERATION OF THE SCIENTIFIC COOPERATION ON SOLAR ECLIPSE OBSERVATION RESEARCHES BETWEEN THE AEROSPACE RESEARCH CENTER OF LAPAN AND JAPAN

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INTRODUCTION

The scientific cooperation between the Aerospace Research Center of Indonesian National Institute of Aeronautics and Space (LAPAN) and Japan on the balloon and ground-based observation researches of the solar eclipse on 11 June 1983 in Indonesia was initiated with a talk about an eclipse balloon observation between Prof. J. Nishimura of the Institute of Space and Aeronautical Science (ISAS) and Dr. R. Sunaryo, Chairman of LAPAN, and the author, head of the Aerospace Research Center of LAPAN, at the time of attending COSPAR Meeting held in Budapest, Hungary, in 1980.

The talk was then followed by a technical discussion in Tokyo when the author attended the international seminar of ISTS held in Tokyo in 1981. In this time, all aspects on the preparation of the cooperation project were discussed, i.e. observation sites, accomodations, procedures of the transportation of all equipments needed from Japan to Indonesia.

Meanwhile on the side of LAPAN, a team of the cooperation was appointed consisting of Dr. R. Sunaryo and Prof. Wiranto Arismunandar, Vice Chairman of LAPAN, as the advisors and the author as the head of the team. The members of the team were mainly the staff members of the Aerospace Research Center of LAPAN.

The Indonesian Government paid great attention on the rare event by organizing a National Committee on Solar Eclipse 1983 consisting of the representatives of various institutes and departments under the coordination of LIPI (The Indonesian Scientific Council). The main goal of the National Committee was to assist all scientists from other countries and the nation itselt as well, taking parts in the 1983 Solar Eclipse Observations in their preparation and on the operation of the observations research, and to give complete information on the total solar eclipse to the Indonesian people.

SURVEYS ON LOCATION, ACCOMMODATION AND SUPPORTING DATA

The first Japan team members coming to LAPAN/Indonesia for a location survey were Messrs H. Akiyama and Y. Koma of ISAS in February 1982. Mr. Akiyama visited again Indonesia in February 1983 to have a discussion with LAPAN team in Bandung, i.e. to get the data of the surveys of locations, accommodations and other supporting facilities such as meteorological condition (rainfall) based on the prediction by LAPAN meteorological team for the regions chosen as the observation sites in the island of Java. Besides, especially for the balloon observation, a detailed discussion about arrangements of the project was made.

LAPAN was busily trying to aim at a target of accomplishment of Watukosek Stratospheric Balloon Launching Station, Pasuruan, East Java, which should be ready before June 1983, and the target was succesfully aimed. The station was formally inaugurated by Dr. Sunaryo on 4 May 1983.

Considering that there was still a doubt about the wind direction at the stratospheric altitude in June 1983, other locations besides Watukosek Stratospheric Balloon Launching Station were also prepared in Central Java (Surakarta and Purwodadi regions) just for the safety of the observing operation in case of westerly wind.

For the ground-based observations, Mojokerto, Cepu, Tuban and Kragan were finally selected as the observation sites.

OBSERVATIONS

Member names of LAPAN and Japan teams for each project at each observation site are listed in Table 1. Preparations, installations and operations of the 1983 Solar Eclipse Observation Researches were conducted by these members.

The observations at Mojokerto and Kragan were made with a fine weather, while it was covered by thin cloud at Cepu and Tuban. The geomagnetic observation at Cepu was successful.

The observation by the balloon, which was launched from Watukosek Stratospheric Balloon Launching Station, was successfully carried out at 30km altitude at a position of about 40km east-southeast from Jogjakarta. Main payloads were recovered safely by LAPAN-Japan recovery team.

Table 1 JAPAN - INDONESIA SOLAR ECLIPSE RESEARCH OBSERVATION COOPERATION

No	Project	Intstitute	Japanese members	Indonesian members	Obs site	Accommodation	Duration
	A. Ground-Based Obs						
1.	Physical structure at the active and polar regions in the corona	Tokyo Astron. Observatory	E. Hiei Y. Shimizu H. Miyazaki H. Imai	Wilson S. S.L. Manurung	Cepu 07°07'52" S 111°35'26" E	Cepu Lemigas Houses	May 10 - June 20 1983
2.	Spectroscopic and monochromatic structures of the chromosphere and corona	Kwasan and Hida Observatories, Kyoto Univ.	S. Saito Y. Funakoshi Y. Suematsu	Suratno	Tuban 06°54'11" S 112°02'55" E	Tuban Private House	ditto
3.	Precise determination of the contact time of the sun and moon	International Latitude Observatory	K. Sato S. Kuji	Chunaeni L.	Mojokerto 07°27'01" S 112°26'40" E	P.T. Aji No Moto	ditto
4.	Precise determination of geometrical configurations of the sun and moon	Hydrographic Department Maritime Safety Agency	T. Kanazama T. Fukushima	Srie Kaloka	Tuban & Kragan 06°42'20" S 111°36'27" E	Tuban & Kragan Private House and in the site	ditto
5.	Eclipse effect on geomagnetic pulsations	Dept. Geophys., Tohoku Univ. and Tohoku Inst. Tech.	T. Saito K. Yumoto Y. Kitamura	M. Pardede	Cepu 07°07'52" S 111°35'26" E	Cepu Lemigas Houses	May 20 - June 20 1983
	B. Balloon-Borne Obs						
6.	Visible and infrared observations of the F corona	Tokyo Astron. Observatory Dept. Phys., Kyoto Univ. Inst. of Space and Aeronautical Science	H. Tanabe S. Isobe T. Maihara K. Mizutani H. Akiyama Y. Koma Y. Okabe	J. Soegijo Tatang T.S. Indrawan Hariadi T.E. Slamet S. Anondo P. V.R. Suroto Mulyana W. Agus Suripto and 20 other personnel.	Watukosek (Pasuruan)	Guest House Pandaan	May 10 - June 20 1983

TIME SCHEDULE FOR THE OBSERVATION

1979 Oct. 13		Discussion on Indonesia eclipse at National Committee for Solar Eclipse, Science Counsil of Japan.
1980 June		Discussion on scientific cooperation of balloon experiment between ISAS (Prof. J. Nishimura) and LAPAN (Dr. R. Sunaryo and Ir. J. Soegijo).
1981 May		Application of the eclipse project to Ministry of Education, Science and Culture.
	Aug.	S. Isobe visited Cepu and Tuban.
1982 Feb.		H. Akiyama and Y. Koma visited Bandung and Watukosek.
	March	Application to Special Project Research.
	April	Contact to National Committee for 1983 Solar Eclipse (LIPI).
1982 June		Application to Overseas Scientific Research.
	Aug.	Presentation of observing plan to Ministry of Foreign Affairs.
	Nov.	J. Nishimura visited LAPAN.
	Nov. 9	Meeting of eclipse team.
1983 Jan. 10		Asking Ministry of Foreign Affairs for giving benefit.
	Feb. 28	Collection of all wooden cases of equipment for optical ground-based

		observations (TAO, 54 cases, 5.8tons in gross weight, 27m^3; Kyoto Univ., 36 cases, 4.6tons, 19m^3; Intl. Lat. Obs., 38 cases, 4.4tons, 24m^3; Hydr. Dept., 26 cases, 2.2tons, 9m^3) (ship cargo).
	Feb.	H. Akiyama visited Watukosek, Cepu and Tuban.
	March 4	All cases, kept in three containers (two 20-feet containers and one 40-feet container), were shipped from Yokohama by "Tokyo Maru".
	March 10-11	G.Ishida visited Watukosek, Mojokerto, Cepu, Tuban and Kragan.
	March 31	"Tokyo Maru" arrived at Surabaya.
1983	April 14	Collection of all cases of equipment for balloon and geomagnetic observations (air cargo).
	April 22	Air cargo left Narita.
	24	S. Saito left for Indonesia.
	May 5	Seals of containers were found to be broken at bonded warehouse of Surabaya customs during process of customs clearance.
	May 7	Survey of robbery by customs authorities.
	May 9	E. Hiei, Y. Shimizu, H. Miyazaki, H. Imai, Y. Funakoshi, Y. Suematsu, K. Sato, S. Kuji, H. Tanabe, H. Akiyama, T. Kanazawa, and T. Fukushima left Narita for Indonesia.
	May 14	Customs clearance of air cargo at Jakarta.
	16	Customs clearance of ship cargo at Surabaya. Each team members left for Cepu, Tuban and Mojokerto.
	18	H. Tanabe and H. Akiyama arrived at Watukosek.

	21	S. Isobe, Y. Koma, S. Okabe, T. Maihara, K. Mizutani, T. Saito, K. Yumoto, and Y. Kitamura left for Indonesia.
	22	Balloon members arrived at Watukosek.
	25	Geomagnetic members arrived at Cepu.
	27	M. Seto and T. Tamura left for Taiwan.
June	7	T. Tamura returned back to Japan.
	11	Total solar eclipse.
	15	All wooden cases were collected in warehouse in Surabaya.
	16	All cases for air cargo were collected at Jakarta.
	17	K. Yumoto, and Y. Kitamura arrived in Japan.
	20	Y. Shimizu, H. Miyazaki, H. Imai, Y. Funakoshi, Y. Suematsu, S. Kuji, S. Isobe, Y. Koma, S. Okabe, T. Maihara, K. Mizutani, T. Saito, T. Kanazawa, and Y. Fukushima arrived in Tokyo.
	22	E. Hiei, K. Sato, S. Saito, H. Tanabe, H. Akiyama arrived in Tokyo. Air cargo arrived in Japan.
July	25	Ship cargo arrived in Yokohama.

THE OBSERVATION OF THE TOTAL SOLAR ECLIPSE AT CEPU, INDONESIA

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ABSTRACT The total solar eclipse on 11 June 1983 was observed at Cepu, Central Java. Electron number density in thread-like fine structures in an active region of the corona was derived to be about $5 \times 10^{+9}$ from the corona taken at the eclipse. Observation instrument, observation procedures, and data analysis are described.

1. INTRODUCTION

A total solar eclipse is a good opportunity for photometric and geometric study of coronal fine structures, which are probably related to magnetic field lines. If energy dissipation in the corona is closely related to the magnetic field, the physical state of the fine structures and their surroundings would be different from that of a rather uniform corona.

Foot points of the fine structures are inferred as facular points in the chromosphere, but observationally, it is difficult to identify a relation between the foot points of the fine structures and the facular points because of a large intensity difference between them.

A dynamic range of a photographic film is at most 10^3, which is small compared to an intensity contrast of the inner and outer corona, and therefore a radially gradient filter is used for taking an image of the overall structure of the corona.

This method has been proved to be effective to study the coronal streamers. The drawback, however, is to photograph the inner corona with a longer exposure time; the inner corona can be taken with much short exposure time without the filter.

In order to take images of fine structures in the corona and the chromosphere, a large image size as well as a short exposure time, not blurred by seeing, are important.

The total solar eclipse in Indonesia is one of the best opportunities because the duration of totality is long, the weather is expected to be dry, and the transportation of observation equipment is convenient to accomplish.

Studying the fine structures in the corona is our main goal for the observation at the Indonesian eclipse and the observation instruments, observation procedures, and its result are described as follows.

2. OBSERVATION INSTRUMENTS

Two instuments were used for taking images of fine structures of the corona and the chromosphere with and without a filter of linear polarizer; one is a horizontal telescope and the other an equatorial telescope, which are shown in Figure 1 and 2.

The horizontal telescope with a doublet lens of 20cm in aperture and 11m in focal length gave a solar image of 10cm diameter at its focus, where there was a camera holder movable in the direction perpendicular to the light path. A large aerial WILD camera, made in Swiss, was attached to one side of the holder and four 35m/m Nikon motor driven cameras to the other side. During the totality, the aerial camera or 35m/m cameras were easily and rapidly moved in order to take the solar image. Figure 4 and 5 show a sketch of the horizontal telescope and its camera part, respectively.

A sharp cut filter of an 0-57 of 283mm in diameter was put in front of the aerial camera, and a whole image of K corona up to 2 solar radii was taken on Kodak Plus-X aerographic film 2404. Four 35m/m cameras were set at the east and west equators of the Sun, and at the north and south poles. There was a turret for filters in front of the 35m/m cameras, in which there were two interference filters for 5303A (bandwidth 3.7A) and two interference filters for 5000A (bandwidth 450A), in order to take images of a part of E and K corona. The same filters were placed on the opposite side. The Nikon cameras were modified so that exposure times could be controlled by a hand-made micro-computor.

A configuration of the coelostat was such that the relative motion of the Sun to the Moon was horizontal, and the solar image was stopped. The relative position of the coelostat and the second mirror was determined from the formula by Kristenson (1959); the altitude and azimuth (measured from the north point eastward along the horizon) of the second mirror relative to the coelostat were 73° .0 and 163° .3, respectively. The direction of the reflected beam from the second mirror was 343° .3 in azimuth.

The 20cm-aperture equatorial telescope with a doublet lens of 225cm in focal length had a filter box and a camera at the focus. In the filter box there were two sliding filter cases, each had two filters; an interference filter of 5780A (bandwidth 400A) and an interference filter of 5303A (bandwidth 3.7A) on one slide, and a linear polarizer and a flat glass of heat absorber on the other slide. The polarizer rotated 360° in 45° step. Figure 6 shows a sketch of the equatorial telescope.

A whole image of the corona was taken with 6×7 size Asahi Pentax with 70m/m film of Kodak Tri-X 2B. The Pentax camera was also modified so that winding up of the film and shutter release were controlled by the micro-computor. One camera took the coronal images of only 20 frames, and thus another camera was set during the totality after the first camera was all exposed.

A video camera was attached to the equatorial telescope for guiding. ND filter was put in front of the video camera during the partial eclipse. The placing and removing of the ND filter was controlled by the micro-computor.

Temperature control of the all interference filters was made within 0.1℃ and the filter temperature was checked by a thermister.

It is important to take a photograph with an appropriate exposure time at a definite time for an eclipse photography, because the contrast of the intensity of the solar disk, chromosphere and corona is much larger than the latitude of photographic film. Therefore timing and exposure times were automatically controlled by the micro-computor. Figure 7 shows the micro-computor and its related equipment.

Driving systems of the coelostat and the equatorial telescope were made with AC 100V synchronous motors, which was supplied through an inverter from DC 12V batteries on the eclipse day.

3. PREPARATION AND OBSERVATION

Our observation equipment was set at an area in front of LEMIGAS (Indonesian Institute of Oil and Gas) houses where we stayed from 16 May to 15 June. The geodetic position, determined by Doppler observations of NNSS satellite with Geoceiver (Magnavox MX 1502), was E 111° 35'25"91 at longitude, S 7° 7'52"35 at latitude, and 92.1m high from sea level.

The observing site was determined when all of us and Mr. Manurung (LAPAN) visited Cepu on 13 May during the process of the customs clearance of our equipment. Staff members of LEMIGAS, kindly took us to several areas suitable for our observation, and the observing site mentioned above was decided upon. We asked a staff member of LEMIGAS to make concrete bases for the equatorial telescope, coelostat, and camera part of the horizontal telescope at that time. The customs clearance of our equipment was finished on 16 May and two trucks transported them from Surabaya to Cepu. All of us and Mr. Manurung followed the trucks and arrived at Cepu at mid-night on 16 May.

Opening of the boxes of our equipmet, rough determination of north- and south-direction by the solar position near noon, determination of the exact positions of the piers, and concrete bases were carried out until 21 May. Rough setting of the horizontal and equatorial telescopes was made in 22-27 May, and fine adjustment, focus test, and exposure test were made in 28 May-2 June. The rehearsal for the eclipse observation was carried out once or twice a day from 3 June, especially in the evening in order to get used to performing in the dark.

On 11 June, the eclipse day, the sunrise was seen, but thin clouds began to appear from the east and became thicker and thicker. Our observation started, following the planned program, which was controlled by the micro-computor. The starting time of the program for the horizontal telescope was made by measuring a length of the cusp of the sun at 7 min. before the second contact, and the program for the equatorial telescope started at 4 min. 55 sec. before the second contact. Exposure times and filter changes for 35m/m and 70m/m cameras were automatically controlled by the micro-computor, but exposure times for the large aerical camera were made by hand. Therefore the coronal observation by the aerial camera was taken with 30 sec. exposure, 10 times longer than the planned exposure time. Every cameras and equipment worked very well. For the calibration, the solar disk was taken with various ND filters one and two days before the eclipse and just after the eclipse on the films of the same roll as those used during the eclipse.

Packing of the equipment was made on 12-14 June and on 15 June all boxes of the equipment were carried to Surabaya by 2 trucks and we also left Cepu for Surabaya.

4. DATA ANALYSIS

All the films taken with the horizontal and equatorial telescopes were thought to be too underexposed because the observation was made under clouds. We tried to develope the films as dark as possible, but many films showed thin coronae. However, the corona above an active region at the west taken with the exposure time of 30 sec. by the aerial camera turned out to be usable for analysis as shown in Figure 3.

An optical thickness of the clouds during the eclipse observation seemed to be about 2 from the appearance of the coronal images on the films. The clouds were not uniform, and of wave-like appearance. A wavelength of the clouds was around 1 solar radius at some regions or 0.1 solar radius at the others.

The coronal image taken at Cepu is more or less affected by clouds, and the absolute intensity of the corona or the coronal structure in large scale seemed not to be appropriate for studies from our data. However, a small scale structure of the corona may not be affected by the irregulatity of the clouds.

There appear thread-like fine structures of the corona above the active region at the west limb on the film taken with the horizontal telescope. The film was traced with a microphotometer at the Tokyo Astronomical Observatory. Figure 8 shows the brightness distribution of the corona at an effective wavelength of 5800A. The equal brightness is shown in real lines in Figure 8, where I_0 means the brightness at the disk center at the same wavelength. The absolute brightness is estimated in such a way that the brightness of the corona above the equator at the west limb besomes equal to that derived from the data observed by Sato and Kuji (1985). The position of the thread-like fine structures are shown as A,B,C,----H in dots in Figure 8. The widths of these fine structures, on the average, are about 10 arc sec., which is probably much smaller than the irregularity of the clouds. Therefore the excess brightness of the fine structures above that of the background corona seems to be safer for analysis than the shape of K corona. If the length of each fine structure in a line of sight is the same as its width, the electron densities for these fine structures can be derived under the assumption that the brightness is due to Thomson's scattering. Figure 9 shows the derived electron densities for each fine structures of A,B,-----H, and the electron densitiy of the corona above an active region derived by Newkirk (1967). It is to be noted here that the electron density in the corona just above the sunspot, seen in higher brightness in Figure 8, is estimated to be larger than $7\times10^{9}cm^{-3}$ by Suematsu et al. (1985). If the density change with height is the same as Newkerk's model, the electron densities of fine structures of C,E, and F seem to be consistent with theirs.

It is also interesting to compare fine structures above the active region and pole. The widths of both fine structures are about the same, but the density above the active region, on the average, is larger by 5-10 times than that derived at the pole (Hiei, et al. 1985; Sato and Kuji 1985).

ACKNOWLEDGMENT

We would like to express our hearty thanks to the local authorities for safety, security and guards; to LAPAN for arranging the observing site and sending the staff members to help our observations, and to LEMIGAS for providing the observing site, houses, and guardmen for security, especially to Ir. D.P. Muchtisar, Ir. Sunarhadijanto, Ir. Paryono, Mr. S. Hidayat, Mr. R. Soemarso, and many kind staff members of LEMIGAS; and people in Cepu for their kind hospitality. We have no words to show our appreciation Messrs. M. Imaizumi, Y. Mizuta, T. Taniguchi, and many staff members of Marubeni Corporation for their invaluable, important and useful help, and to Mr. H. Arakawa for helping us communicate with the local people.

We express our gratitude to Professors F. Moriyama and T. Hirayama, to our staff of Solar Division, Norikura Solar Observatory, Mechanical Fuctory Division, and Administrative Division at the Tokyo Astronomical Observatory. The research was carried out under the support of a Grant in Aid of Overseas Scientific Research, and of Special Project Research, Ministry of Education, Science and Culture, Japan.

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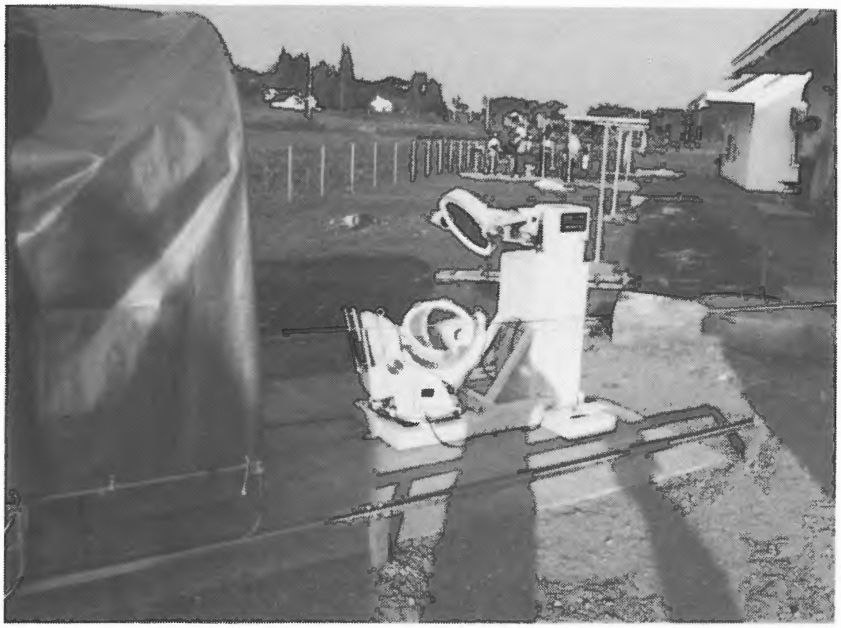


Fig. 1(1). Coelostat.

Fig. 1(2). Camera part of horizontal telescope.

Fig. 1(3). Observing site and houses for accomodation.

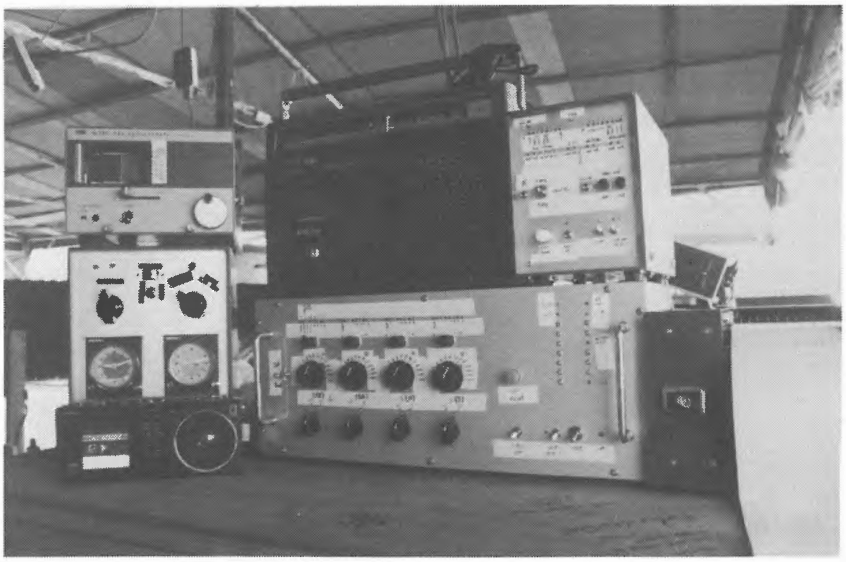


Fig. 1(4). Micro-computor for controlling observation equipment.

Fig. 2(1). Equatorial telescope.

Fig. 2(2). Camera part of equatorial telescope.

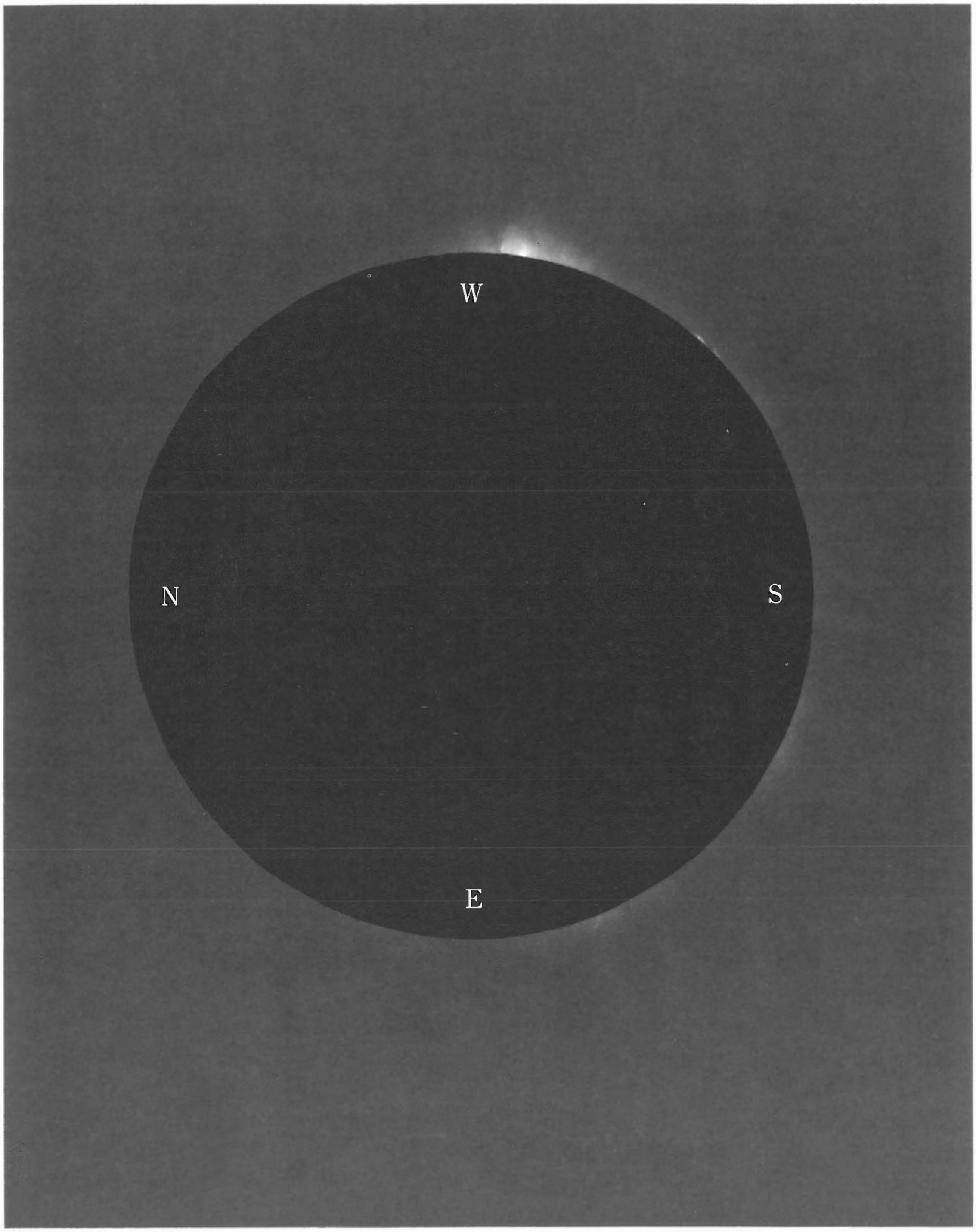


Fig. 3. Photograph of the corona taken with horizontal telescope.

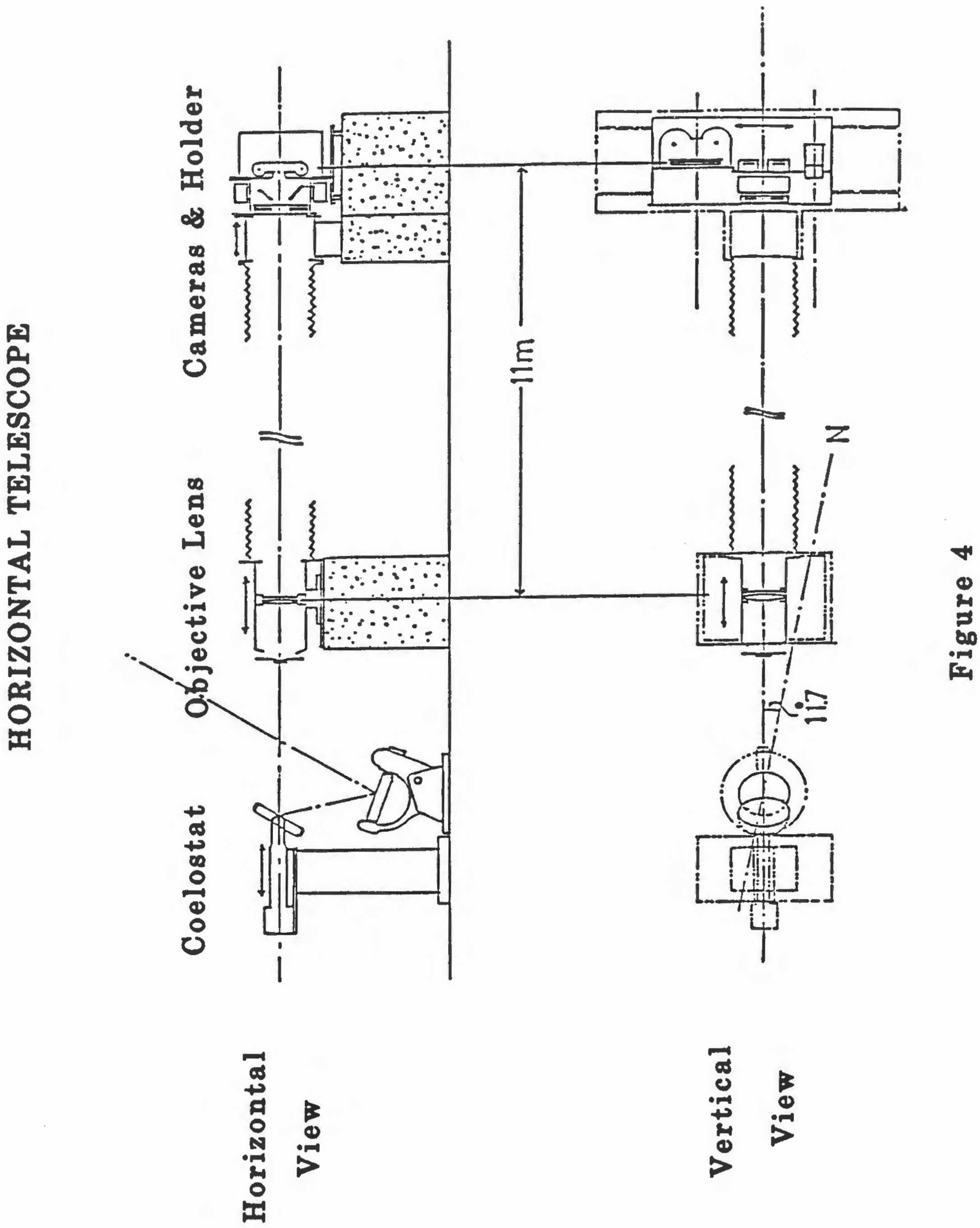


Fig. 4. Sketch of horizontal telescope.

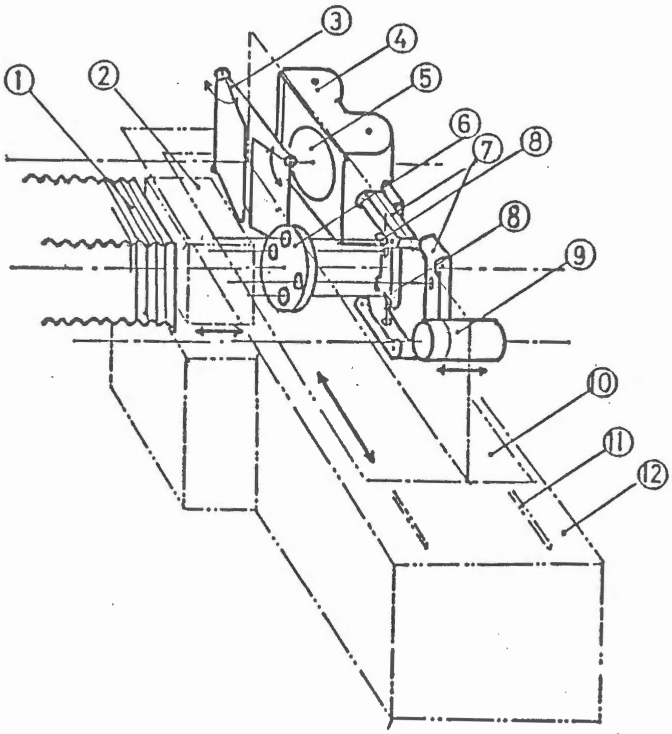


Fig. 5. Sketch of camera part.

(1) Bellows
(2) Movable Food
(3) Shutter operated by Hand
(4) Aerial Camera
(5) Sharp Cut Filter (0-57)
(6) Turret for filters
(7) Nikon Camera
(8) Mirror
(9) Focus Viewer
(10) Camera Holder
(11) Rail For Shifting the Camera Holder
(12) Concrete Pier

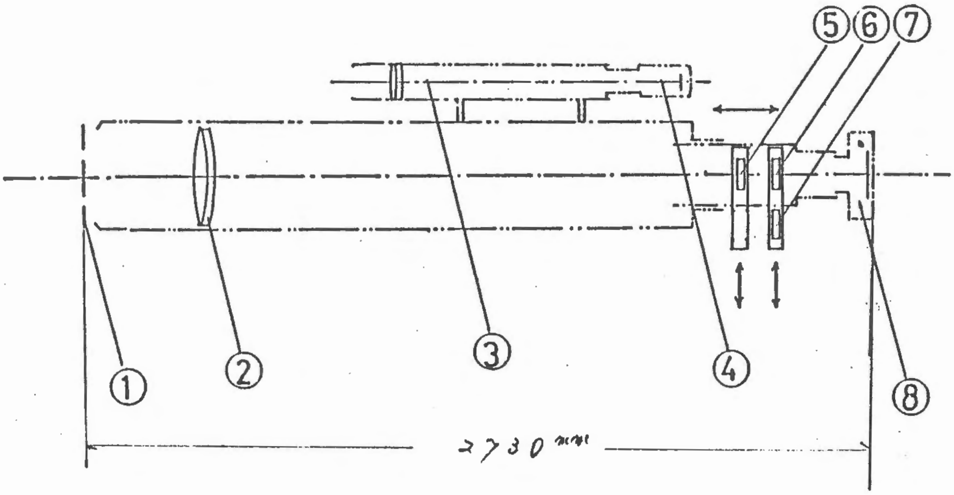


Fig. 6. Sketch of 20cm-aperture equatorial telescope.

(1) Diaphram for Photometric Calibration

(2) Objective Lens (ϕ=20cm. f=225cm)

(3) Guiding Telescope

(4) Video Camera

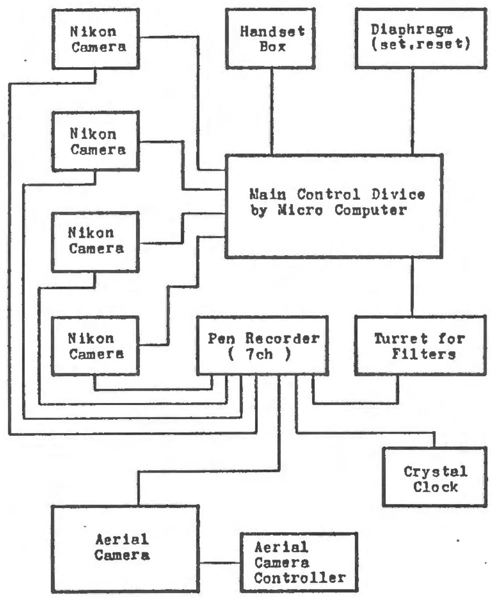
(5) Filter of Linear Polarizer

(6) Interference Filter (5303A)

(7) Interference Filter (5780A)

(8) Camera (Asahi Pentax 6x7)

Aerial Cameras



Equatorial Telescope

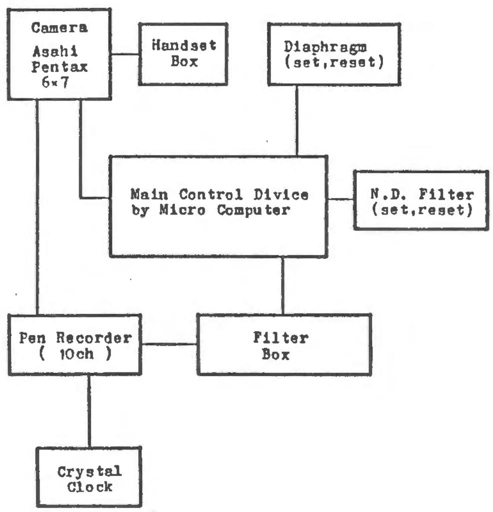


Fig. 7. Diagram of controll system.

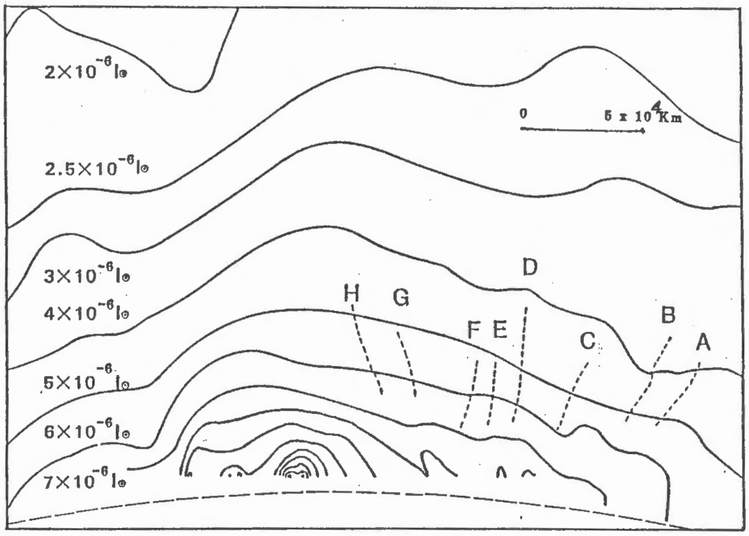


Fig. 8. Iso-intensity curves and fine structures in the active region at west limb.

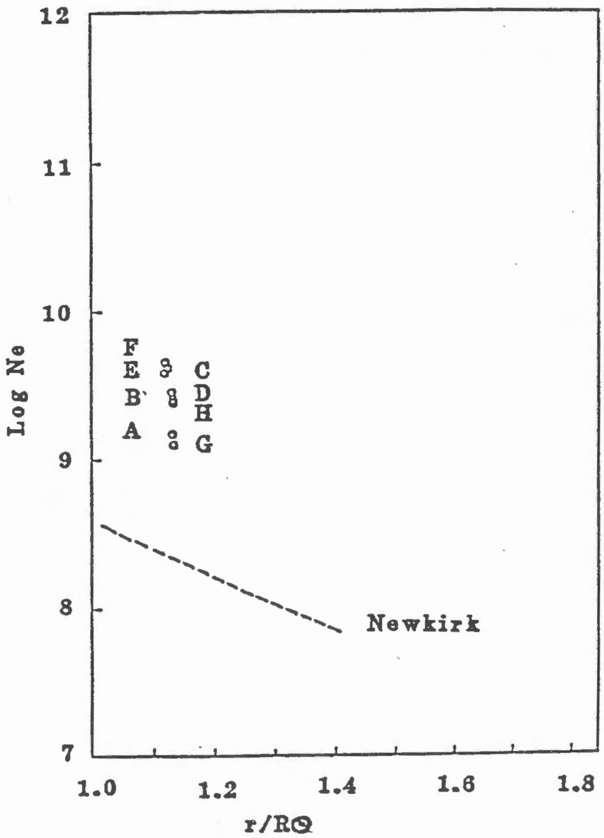


Fig. 9. Electron number density of fine structures and Newkirks' model.

THE 1983-ECLIPSE OBSERVATION AT TUBAN, EAST JAVA, INDONESIA

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I. Introduction

In the fall of 1980, three of us (S.S., Y.F. and Y.S.) started a basic survey for the 1983-eclipse in Indonesia. Our main aims to this eclipse were how to get more accurate information on the structures of the chromosphere and corona as much as possible, and to study how low the coronal material immigrates into the chromopsheric layers. By virtue of the accumulation of the experiences obtained by the staff of our Observatories at the preceding expeditions, and of ephemeris informations supplied by the staff of the Hydrographic Department, the Maritime Safety Agency of Japan (JHD), circumstances of the eclipse were examined both on the scientific and technical points, and the following plans were achieved: (1) information for wide-range structure of corona can be provided by multi-channel narrow-band photometry, (2) spectroscopic method is useful to examine the physical conditions in both chromosphere and corona, (3) combination of both methods (1) and (2) plays a complementary role each other, and (4) slit-spectroscopy would give more precise information for the line-profiles of the chromospheric and coronal lines, if it is technically allowed. Since then, in the fall of 1981, several trial designing procedures were persuaded in astronomical and technical views, *i.e.*, spectral range of coronal emission lines, spectral dispersion and efficiency of the spectrograph, controlling mechanism of the telescope-driving and of actions of camera, and height resolution of spectra. All of them were connected each others. Finally, we decided to adopt the 4-channel narrow-band phtometry and slit-spectroscopy as the observational plans at this eclipse expedition. In this stage of planning, assumed poistion of the observing site was estimated on the TPC M-11DG chart of scale 1:500,000. Details of the equipments are described in the following section.

During the months of 1982 Oct. to 1983 Feb., all of the apparatus were assembled and carefully tested at the Kwasan Observatory. Essential

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requirements of the designing policy were achieved and confirmed by rehearsals.

II. Insturmentation

II.1. The 4-Channel Monochromatic Image Telescope: The 4-channel telescope consists of four refractors, assembled on a spar of rigid tube of 50cm in diameter and 1.5m in length, on a fork-type equatorial mounting. This instrument was developed by the 1976-expedition team (A. Hattori, J. Kubota and H. Kurokawa) to study the heterogeneous structures in the lower corona. At the 1980-eclipse in Kenya, this telescope firstly succeeded to get high resolution pictures of coronal loops in the light of FeX 6374, FeXIV 5303, Hα and the 6100-continuum (Saito *et al.* 1981, Hanaoka 1985). The essential aspects of this instrument, with some minor improvements for the 1983-eclipse, are described in the following section. Full view of the telescope is shown in Figure 1.

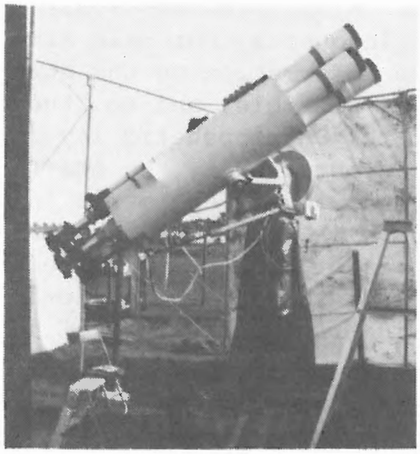

Figure 1.

The 4-Channel Telescope

The front-plate of the main-tube mounts four doublet objectives: three of them have 15cm aperture, f/15 and the fourth, 10cm, f/15. The rear-plate carries four tube-end units, each of which consists of relay-lens system, monochromatic filter and 35-mm motor-driven camera. Four individual optical paths are separated by the thin inner-tubes set inside the main-tube, to keep isolation from thermal disturbances.

The monochromatic filter is of Fbary-Perot type, fabricated by Del. N. Woods. This filter is thermo-controlled with electric oven in a compact filter-housing and placed in the optical path between the relay-lens system and the camera. Spectral characteristics of the filters are summarized in Table 1.

The relay-lens system is designed to meet the following principal requirements: (1) to maintain the spectral purity of the light transmitted through the filter over the whole field of view, (2) to realize the

TABLE.1. The 4-Channel Monochromatic Image Telescope

Spectral	Range A	FWHM A	Solar Diameter mm	Film*	Exposure Time s ∿ s	No. of Exposures# 2.-E-W-3. = total
FeXIV	5303	1.8	29.6	K-TP	1 ∿ 64	11-6-7-12 = 36
FeX	6374	4.2	29.8	K-TP	1 ∿ 64	11-6-7-12 = 36
FeXI	7892	3.1	29.2	K-HIE	1 ∿ 64	11-6-7-12 = 36
Hα	6563	0.6	30.8	K-TP	1/16 ∿ 64	73-9-9-75 = 166
Continuum	6100	90	4.5	F-NF	1 ∿ 64	11-6-7-12 = 36

* K-TP: Kodak TP 651. K-HIE: Kodak HIE 421. F-NF: Fuji Neopan F

\# Nos. of exposured frames at:
2nd Contact-East Limb-West Limb-3rd Contact = total.

required image size of the Sun on the photographic film-plate, (3) to minimize the additional instrumental broadening of the pass-band of the filter and (4) also to minimize the total length of the system. The lens system consists of two precisely-fixed components: The front concave lens makes virtual image of the telescope objective just in front of the lens system where exit-pupil of the system is settled. The rear convex lens, whose front-focal point is placed at the exit-pupil, refocusses the solar image on the photographic film. Thus this relay-lens system enables all principal rays to pass through the filter in parallel with the transmitted light over the whole field of view. As filter is set nearer to the rear imaging lens, the skew rays covers wider areas of the filter and the local defects on its surfaces would be smeared.

To accomplish sufficient spatial resolution, the field of view of filtergram is restricted to 36' x 24' for the coronal lines and 21' x 14' for the Hα, covering 1/3 ∿ 1/4 of the solar limb, and therefore, the telescope directs to the east limb of the Sun around the second contact and then switches to the west limb during the mid-totality. As a wide-field monitor covering a few solar radii, an auxiliary fifth channel, *i.e.*, a small telescope of 5cm-aperture, f/10 objective, equipped with a wide-band continuum filter, is prepared. It is attached on the main-tube.

A variety of film is used for different spectral regions: Kodak HIE 421 for λ7892 region, Fuji Neopan F for the orange continuum and Kodak TP 651 for other wavelength regions. Exposure time ranges from 1/16sec to 64sec, and numbers of exposures are 166 frames for Hα and 36 for each of oher spectral regions.

II.2. The Spectrograph: The Imaging system for the spectrograph is a 30cm coelostat system and the horizontal telescope of a doublet objective with an aperture of 30cm and focal length of 4.6m, which produces a solar image of 42.1mm in diameter on the entrance-slit plate of the spectrograph. The spectrograph is sophistically designed to accomplish the requirements of three modes of observation in sequence: (1) During the second contact phase, chromospheric spectra of moderate dispersion are taken with use of slit that is placed at the image of the eclipsing lunar limb whose motion to the slit can be compensated by an additional tracking mode applied to the secondary axis of the coelostat. (2) At the totality, slit-spectra of the inner corona and prominence are taken at the several heights. (3) Finally, during the third contact phase, chromospheric flash spectra without slit are aimed in the same spectral ranges as those of the second contact phase. Schematic layout and optical performances of the spectrograph are shown in Figure a and also in Table 2.

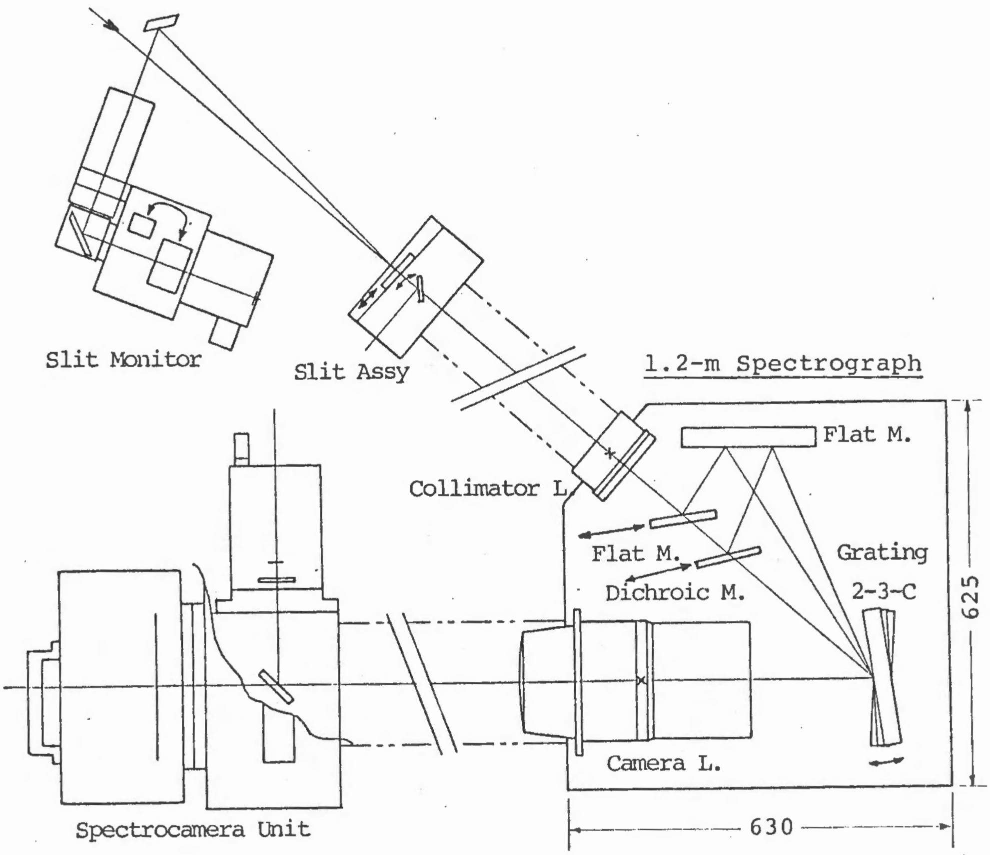

Figure 2. Schematic Layout of the Spectrograph

TABLE 2. The Spectrograph

Mode	Grating Angle α	Grating Angle β	Spectral Range A	Dis-persion A/mm	Exposure Time sec	No. of Exposures* C	No. of Exposures* M
2nd Contact	53°50'	12°50'	3880-4690	3.4	3/4 ∿ 3	25	138
	53°50'	12°50'	7760-9380	6.8	3/4 ∿ 3	25	
Coronal	38°13'	-2°47'	3920-5580	6.9	6 ∿ 48	8	367
	64°13'	-2°47'	6270-7930	6.9	6 ∿ 48	8	
3rd Contact	65°03'	7°03'	3870-4700	3.4	3/4 ∿ 3	27	146
	65°03'	7°03'	7740-9400	6.9	3/4 ∿ 3	27	

* C: Spectrocamera. M: Slit-Monitor.

Slit-plate has four openings of 24mm in height: one curved slit of 21μm-width (≃ 1" of the sly plane) is prepared for the second contact phase, two curved slits of 200μm-width for the coronal mode at the east and west limbs, and a slot of 6mm-width in the minimum for the third contact mode. The spacings between the openings are carefully arranged for easier click-set at every mode-switching.

The mirror0surface of the slit-plate is monitored by a pre-slit optics, which consists of two diagonal mirrors, a 300mm tele-photo lens, filter-housing and a 35-mm motor-driven camera. The monitoring is performed in the Hα monochromatic light for the contact modes and in the white light for the coronal mode in magnification of x 1. In Figure 3 this pre-slit optics assembly is shown.

Just behind the slit-plate, a slot for isolating the slit-openings and a mirror-shutter are equipped. The latter has a high magnification eyepiece which serves for fine adjustment and confirmation of the slit-position to the lunar limb, prior to the start of the program-run.

The collimator is a doublet with an aperture of 10cm and 1.2m in focal length. The collimated beam directly illuminates a grating in the second contact mode. For the coronal mode, it splits into two paths by a slide-in dichroic mirror: The shorter wavelength light passes through it toward the grating. The longer part is reflected twice and hits the grating with a larger incidence angle. For the slit-less third contact mode of the observation, so-called grazing incidence method is prefera-

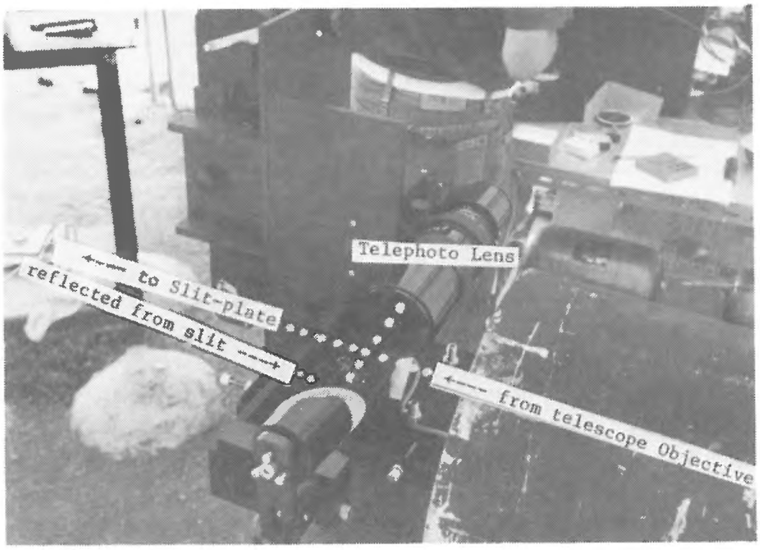

Figure 3. Slit-Monitor Assembly

ble. Therefore, by inserting the second slit-in mirror into the collimated beam, the incidence angle is increased to 65°03', which results in the spectral minification of a factor of 2.35. Such procedure of mode-switching as well as grating rotation is performed at each instance in single manual action by an observer.

Diffraction grating is of 26°45' in braze-angle and 102 x 204mm^2 in ruled area of 1200 grooves/mm by Bausch and Lomb. The camera lens of the spectrograph is wide-field triplet of 17cm-aperture and 1.2m in focal length. These are shown in Figure 4.

At the spectrocamera unit, the in-comming beam is separated into two spectral regions by 45°-tilt dichroic mirror: the blue region passes through it and images on Kodak Tri-X film at the spectrocamea of an aperture of 24 x 240mm^2, and the reflected infrared part focusses on Kodak HIE 421 film of the second spectrocamera. These spectrocameras are specially designed for the Domeless Solar Telescope of the Hida Observatory, with film capacity of 15m in length. The duration of the film-advancement is less than 0.6sec per frame.

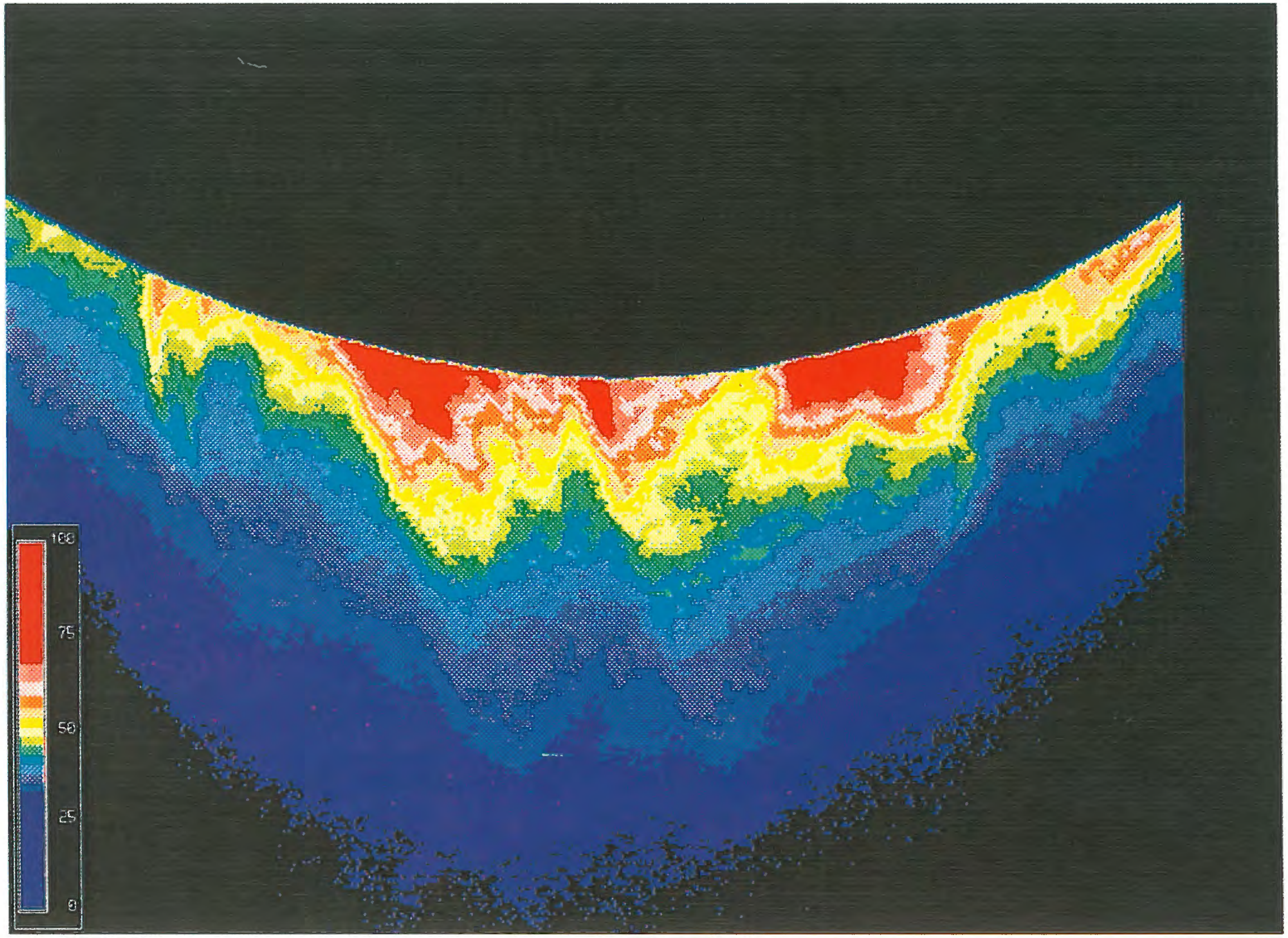

Fig. 22. False-coloured iso-intensity map of FeX 6374 video images of east limb corona. North is to the left.

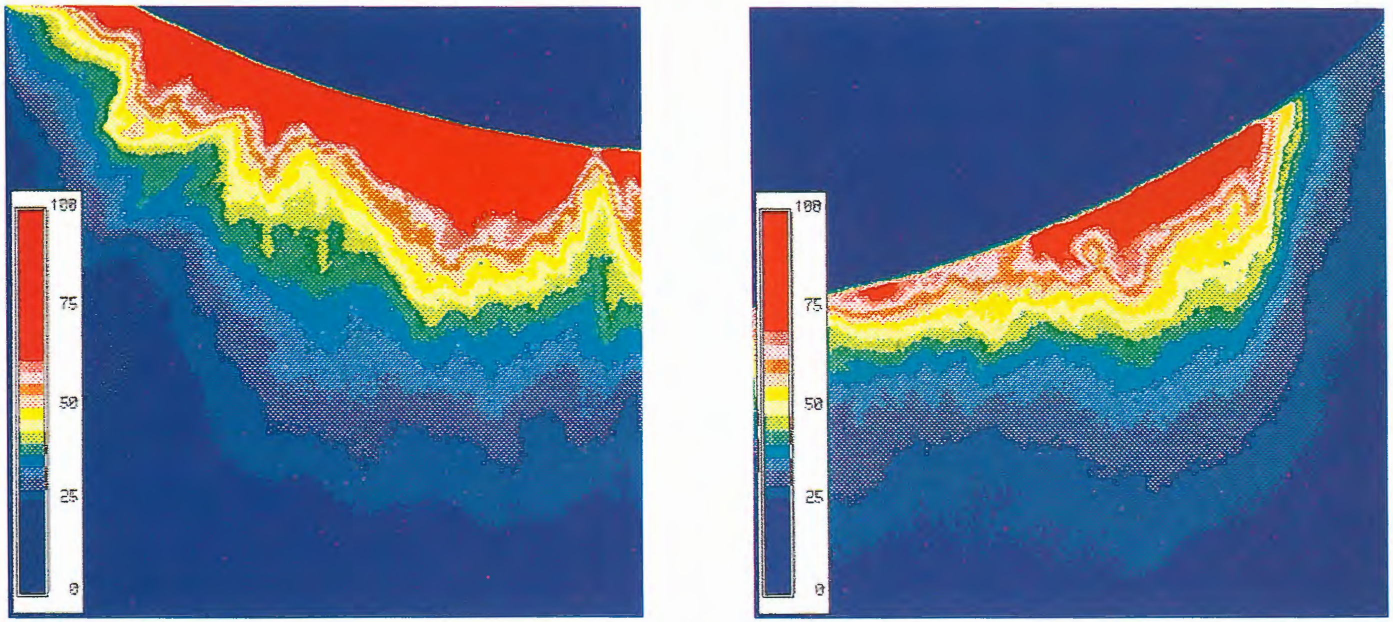

Fig. 23. False-coloured iso-intensity maps of FeXIV 5303 video images of two parts of east limb corona. North is to the left.

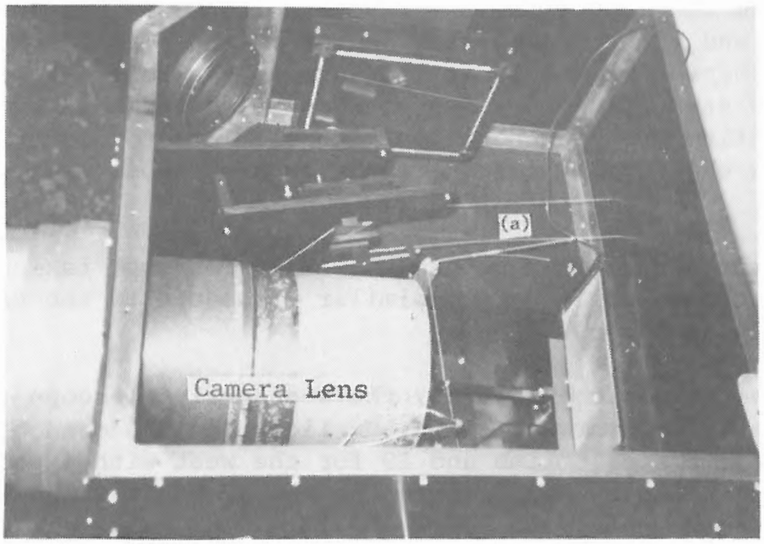

Figure 4.

The Spectrograph

(a): wirings for manual operation at the mode-switching.

III. Observational Scheme

After a series of ephemeris simulations, observational scheme at the eclipse day is assumed in advance and programmed in the sequence-controller. Some procedures are also tape-recorded, vocally, and playing back starts at XXh XXm XXsec, which should be set up after actual astro-geodetic surveying at the observing site, around 720sec before the predicted second contact time. It announces time lapse, important instructions at the several checking time-points. At -33sec of the second contact, a red-button on the sequence-controller is pressed to start the automatic program-run. All of the eight cameras start the exposures according to the inputted program as following.

As the first step, *i.e.*, in the second contact mode, the secondary flat of the coelostat is tracking the motion of the lunar limb. The spectrocamera takes 16 frames of 3/4sec exposure every 1.5sec until -9sec, with the height resolution of 340km and effective height purity of 890km by the integration in height due to finite slit-width and duration of exposure. For the following 6 frames from -9sec to +4sec, the exposure time is increased to 1.5sec, which corresponds to 530km height resolution and of 1060km height integration. After two more exposures for the strongest lines, the second contact mode finishes at +12sec and the system is switched to the coronal mode. In order to supplement rather poor resolutions of the spectra in height, and to clearify the corresponding chromospheric features to the slit-spectra, both of 71 and 128 frames of the Hα monochromatic light limages are taken by the 4-channel telescope and by the slit-monitor, respectively, with exposure time of 1/32sec to 1/2 sec.

Coronal mode continues 375sec including interruption for jumping from the east limb to the west limb. Spectral exposures of this mode are four for each limb, and the entrance-slit is set at the possible minimum height, not to *be eclipsed* by the lunar limb during the long exposure. So the slit-plate is step-slided for every exposure to the next by manual operation. To confirm the slit-position, the slit-monitor camera runs continuously, taking white light images of the 1/2sec exposure evey 3/4 sec.

Final mode starts at -13.7sec before the third contact, taking 27 slit-less flash spectra in the inversed similar procedure to the second contact mode and ends at 35sec.

Besides the spectroscopic exposures, the 4-channel telescope takes monochromatic images in the coronal lines, Hα light and the orange continuum, 17 exposures for the east limb and 19 for the west with exposure time of 1sec to 64sec between -10.5sec to the second contact and +15sec after the third contact.

IV. Operation at Tuban

IV.1. Location of Observing Site and Predicted Contact Time: In the early stage of our preliminary survey, Tuban was already considered as one of the most suitable candidates for the observing site. In the past weather reports, the months of May and June are good season in East Java of low precipitation. Tuban has moderate size of the civil activities and is situated not only at the easily approachable ranges from Surabaya, but also quite neighboring to the central eclipse line that is perferable to our purpose of the project. Around the middle of 1982 August, a survey-team of Lapan reported their findings about the observing sites and lodging facilities around the Tuban Area with their recomendations. We finally decided to accept this advie to settle our observing site at Tuban.

The observing site, thus selected, is situated at a corner of the soccer field of the National Health Center at Tuban, in the southern suburbs of the City and at 3km south from the shoreline of Java Sea. An area of 20 x 20m^2, with whole round clearance of the sky-view above the 15° from the horizon, was shared with the JHD-expedition team. The location, surveyed by the JHD-team, is

Longitude = 112°02'54"E, Latitude = 6°54'11"S,

and predicted contact time in UT for each contact is

2nd contact = 4h32m49.7sec, 3rd contact = 4h37m57.6sec.

therefore, duration of totality is 308sec and our assumed scheme of the program can be safely followed. The timing of the starts are decided:

The Start of Vocal Instructions in tape : 4h20m

The Start of Automatic Program-run : 4h32m16sec.

A series of vocal instructions is taped according above timings.

IV.2. Records of the Operation and Site Plan: Operations at Tuban started in the morning of May 17, with delivery of the quipments and supplies, in 37 boxes, to the observing site. Thenafter, ground surveying, construction works and assembling of the apparatus were continued. The ground plan of the observing site is shown in Figure 5.

Horizontal telescope for the spectrograph lies on the line with an angle of 23°48' to the fundamental North-South line, in 1.2m high and is protruding 3.5m from the observing tent. The coelostat system, in front of it, illuminates 78% of the telescope objective, elliptically, with the effective f-ratio of 1/17. The equatorial telescope is installed at 4.5m off the tent. All basements of the instruments wer fixed with concrete.

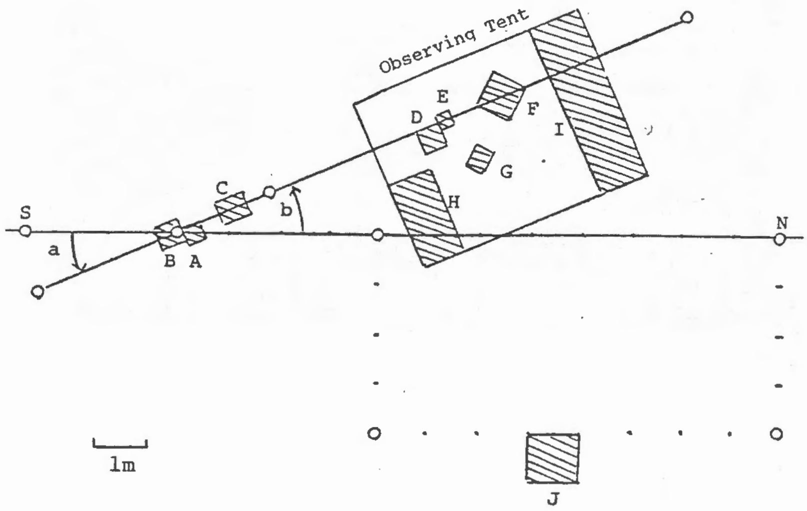

Figure 5. Ground Plan

S-N : Fundamental South-North Line
O : Fundamental Point
a : Direction Angle of 2ndary Mirror Axis (24°2')
b : Direction Angle of Optical Path (23° 48')
A : Coelostat Primary
B : Coelostat Secondary
C : Objective Lens
D : Slit-Monotor
E : Slit-Assembly
F : 1.2m Spectrograph
G : Spectrocamera-Unit
H : Sequence Controller
Pen-Recorder & Batteries
I : Working Desk
J : 4-Channel Telesscope

Inside the tent, are constructed the spectrograph-assembly, a working table and controlling desk, on which sequence-controller, pulse-generator for telescope -drive, rocording devices are allocated. Among them, the sequence-controller is the main device for observing procedures which controls all of actions of instruments on six-channles, in parallel, carrying pre-wired 17-step subprograms per channel. For the event-recording an 8-channel pen-recorder and tape-cassette recorder are prepared. The former records time signals, action timings of shutters of spectrograph and cameras, and brightness level in the spectrograph, and the latter, sound and voice in environment. The controlling desk is shown in Figure 6 with some equipments.

All necessary electric power is supplied with batteries, backed up by a 10kVA diesel generator, placed sufficient far side from the tent.

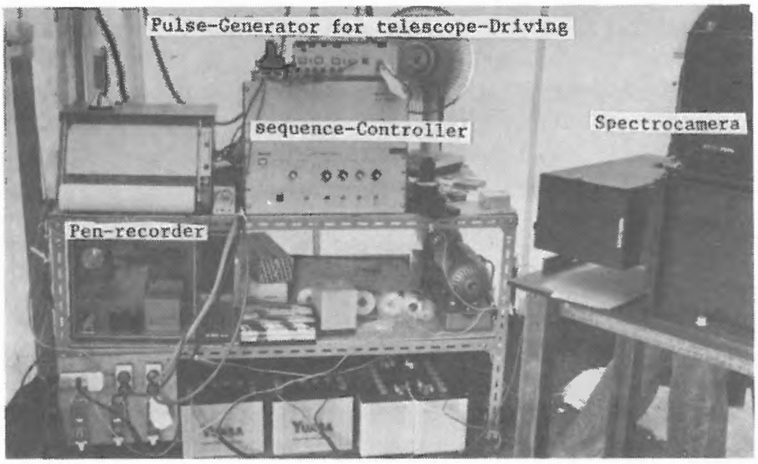

Figure 6. The Controlling Desk

Due to unexpected elongation of wet-season at East Java into late May in the year 1983, scheduled works fo adjustment and test experiments were interrupped, several times, by heavy showers and their accompanied cloudy sky, but final adjustment and rehearsals wer persuaded under the continuation of fine sky in the first seven days in June, and achievement of the preparating works were confirmed.

In the night before the eclipse day, heavy showers attacked us at Tuban, but in the early dawn of the day, the sky was gradually recovering clear though grey clouds were lying low, partly. Unfortunately, rather heavy clouds came to the front of the eclipsed solar disk, a few minutes before the second contact, and the totality proceeded behind the cloud which were getting thinner, with progression of the eclipse.

Under such condition of the sky at the eclipse, our main theme of the project was not achieved, but after returning from Indonesia, the exposured films were processed with sensitization at the Hida Observatory, some images of the corona are found to be worthy to analysing. The reduced results are presented in the following note in this report (Suematsu *et al.* 1985).

V. Acknowledgements

Our eclipse operation at Tuban was achieved under the support, in guards and security and with care in liaison, by all levels of the local authorities, arranged through the Local Eclipse Committe at Tuban. We express our thankfulness to the staff of them, particularly, to Mr. Budiono, of the Office of Social-Politics and to Mr. Sri Kaloka, of LAPAN, who were acting as liaison to local affairs with sufficient advices. Captain and Nyonya Margono took care of us, with generous hospitality during one month of our stay, by whom we could recover some relaxation from the daily works of concentration. Our sincere thanks should go to Captain Margono and his family. We thank to people of Tuban who extended their friendship to us with understanding the project.

we owe much to Messers. T. Kanazawa and T. Fukushima, member of the JHD-expedtion to Tuban, who supplied ephemeris data in advance and their results of surveying at Tuban and supported us by cooperative works in operation.

Of course, we would like to express our gratitude to Professor I. Kawaguchi, the Director and to the staff of our Observatories and also to Mr. S. Kishishita, of the Budgetary and Accounting Section at the Office of the Faculty of Science, University of Kyoto, for their support and continuous encouragements with valuable advices throughout whole stage of this project. Dr. H. Kurokawa was kind to offer the records of his past eclipse expeditions which were quite suggestive and instructive to us. We are much grateful for his generosity and kindness.

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COMPACT CORONAL CONDENSATION OBSERVED AT THE TOTAL SOLAR ECLIPSE OF JUNE 11, 1983

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I. The 1983-eclipse observation was carried at Tuban, Indonesia. As described in the preceding report (Saito *et al.* 1985), the totality at Tuban proceeded in the cloudy sky and some coronal monochromatic images that were persuaded in longer exposures with the 4-channel telescope are obtained which are worthy to analysing. In this note, we present the data observed at this eclipse and some results which could be reduced from them, though the data are small in quantity and poor in quality.

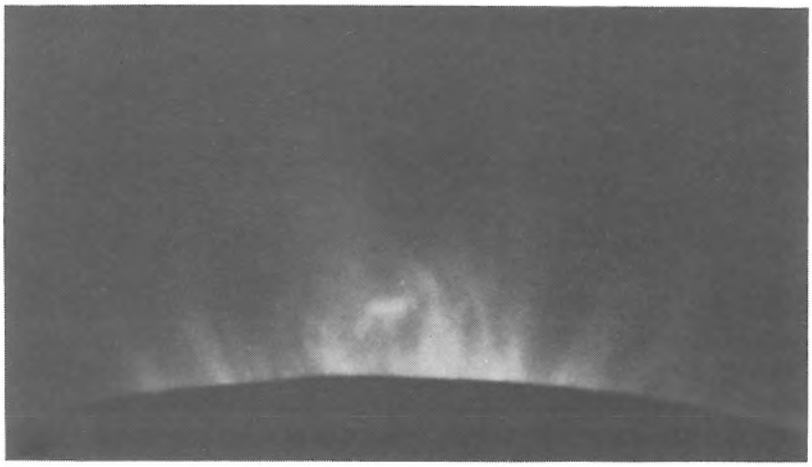
On the eclipse day, there was an active region (Boulder Sunspot No. 4201; Solar-Geophysical Data 1983), just on the west limb of the Sun. The coronal condensation, associated with this active region, is noticeable and the core part of this condensation shows interesting features on the monochromatic images that we obtained. Here we will discuss the morphological features related the core part of this condensation.

Observational data of the some coronal images of rather high quality are shown in Table 1. Spectral characteristics of the filters are cited in the preceding report (Saito *et al.* 1985). The best of them, observed on the east and west limbs are presented in Figure 1, respectively. These filtergrams were taken while the cloud was running over the eclipsed solar disk, and any assumption for the actual duration of exposure and essential timing and amount of the exposure can not be realized. Therefore, we gave up the absolute photometric calibration procedures for them and restricted ourselvs to study the morphological characteristics of the coronal features on the west limb.

II. Iso-density maps of the coronal filtergrams are obtained with the PDS μ10 microdensitometer and the image processing system of VAX-11/750 (KIPS) at the Kwasan Observatory. Examples of them are given in Figure 2 for FeXIV 5303 and FeX 6374 filtergrams at Time B of 32sec exposure. Coronal condensation is seen on each map and the core part that is the brightest region on the map is located at the height of about 20 10^4km above the lunar limb. The shape of the core part in FeXIV light is, however, different from that of FeX 6374 image. The exact height of the core part is different each other.

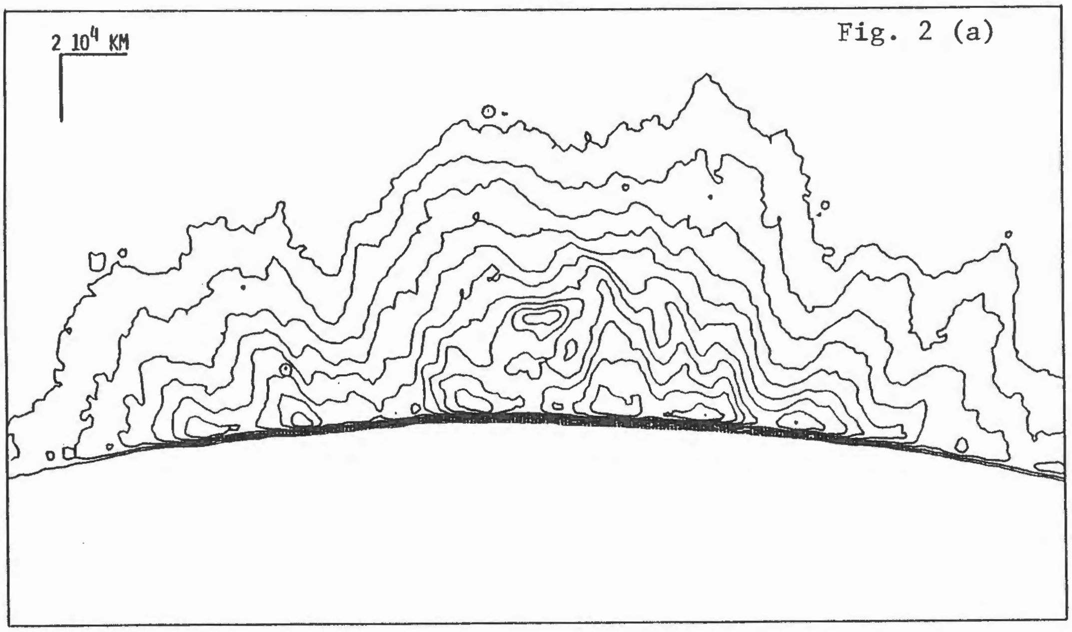
Figure 1. Monochromatic Images of Corona

(a) East Limb
in FeXIV 5303
at Time (A),
64sec exposure



(b) West Limb
in FeXIV 5303
at Time (B),
32sec exposure

(c) West Limb
in FeX 6374
at Time (B),
32sec exposure



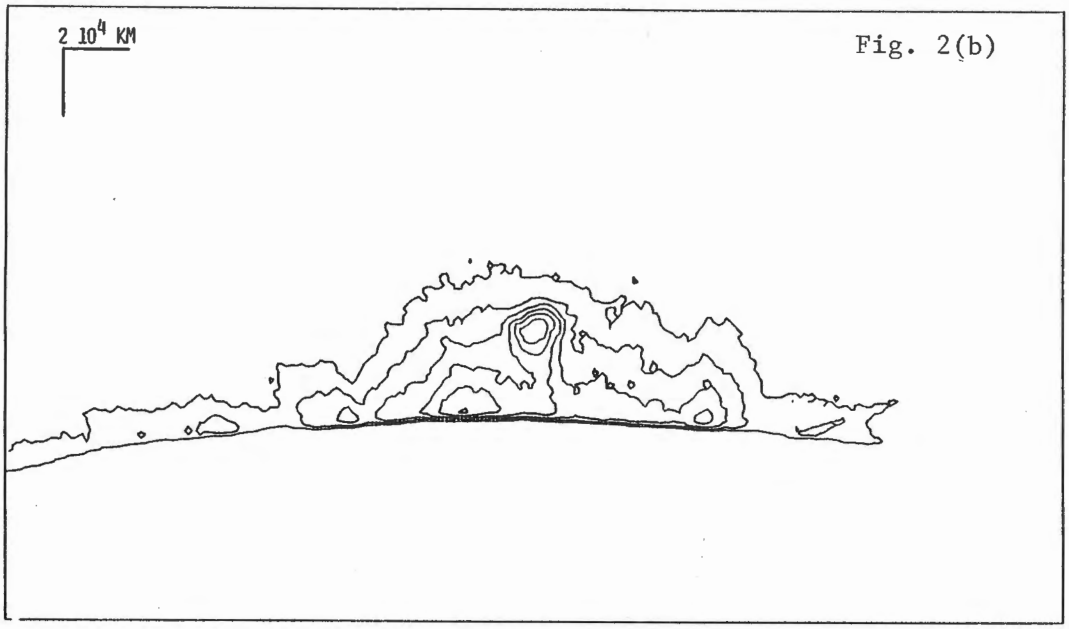


Figure 2. Iso-Density Maps at Time (B).

(a) : FeXIV 5303. (b) : FeX 6374.

TABLE 1. Data of Coronal Images

	Time (4hUT)	Exposure sec	Wavelength		Remarks
(A)	34m 15sec ∫ 35m 19sec	64	FeXIV FeXI FeX Hα continuum	5303 7892 6374 6563 6100	East Limb
(B)	36m 07sec ∫ 36m 39sec	32	FeXIV FeXI FeX Hα continuum	5303 7892 6374 6563 6100	West Limb
(C)	36m 56sec ∫ 37m 12sec	16	FeXIV FeX Hα continuum	5303 6374 6563 6100	West Limb
(D)	37m 30sec ∫ 37m 38sec	8	FeXIV FeX continuum	5303 6374 6100	West Limb

The shape of the core part in FeXIV 5303 light seems to represent the top of an arcade that consists of a few loops (Figure 1(b)). On the other hand, the core part in FeX 6374 light is round in shape and seems not corresponding to the exact top of this arcade (Figure 1(c)). The coronal condensation in FeXI 7892 light has similar structure to that of FeX 6374 image. In the Hα filtergram there is a round-shape and suspended prominence which is similar in shape with, but smaller in size than, the core part in FeX 6374 image.

In order to know the height of the core part from the solar limb, the iso-density maps of the filtergrams at Time (C) and (D) with 16sec and 8sec exposure, respectively, are processed. The latter filtergrams that were obtained at about 30sec before the 3rd contact show a low lying prominence under the core part of the coronal condensation. The lunar limb is not detected on the Hα filtergram and the exact height of the Hα prominence can not be derived. The height and size of the core part of the condensation are shown in Table 2. It is interesting to mention that the core part in FeXIV 5303 is higher by about 5 10^3km than that in FeX 6374 image.

TABLE 2. The Height and Size of Core Part of the Coronal Condensation

Wavelength	Height of the Brightest Point* (10^3km)	Core Size (10^3km) H	Core Size (10^3km) V #
FeXIV 5303	61	17	7
FeX 6374	56	12	12
Hα 6563	56	6	9

* Height from the photospheric limb.

H: Horizontal size. V: Vertical size.

III. Around the eclipse time, a series of Hα filtergrams was taken with using the Domeless Solar Telescope (DST) at the Hida Observatory to back up the eclipse observation which served for the additional informations. These filtergrams, taken from 4h32m 46sec UT to 4h56m 6sec, show a suspended or small loop-type prominence near the region of the core part of this condensation. This Hα prominence which was found as the active and changing feature of apparent shape with time did not exist at 3h46m UT and had disappeared by 6h 32m already. The lifetime of this Hα prominence may be 2 hours or so.

The iso-density map of the Hida Hα filtergram was made to find the height of the prominence from the solar photospheric limb. The variation of height of the prominence and height of the core part of the condensation in FeXIV 5303 and in FeX 6374 images are shown in Figure 3. The prominence is lower than the core part of the condensation before the eclipse time, but it becomes higher gradually and about 20min later, it reaches about the same height of the core part of the FeXIV 5303 coronal condensation.

IV. We may assume that the FeXIV 5303 line is emitted from the plasma of 2 10^6K becasue the maximum concentration of FeXIV-ion is attained at this temperature of 2 10^6K. Similarly, FeX 6374 and Hα lines are emitted from the plasma of about 10^6K and 10^4K, respectively. Thus Figure 3 means that there is a vertical temperature structure in the coronal condensation. The higher temperature plasma is located above the lower temperature one. Such a structure is common in the flare loops and/or the post-flare loop system (*e.g.*, Cheng and Widing 1975, Moore *et al.* 1980). Hence it may be suggested that the core part of the coronal condensation observed at this eclipse time is related to a flare actively.

It seems from Figure 3 that the cooling time of the 2 10^6K plasma to 10^4K plasma is less than 20min. If the plasma cools through radiation, the characteristic cooling time is estimated by the relation $\tau = 3kT/\Lambda/n$,

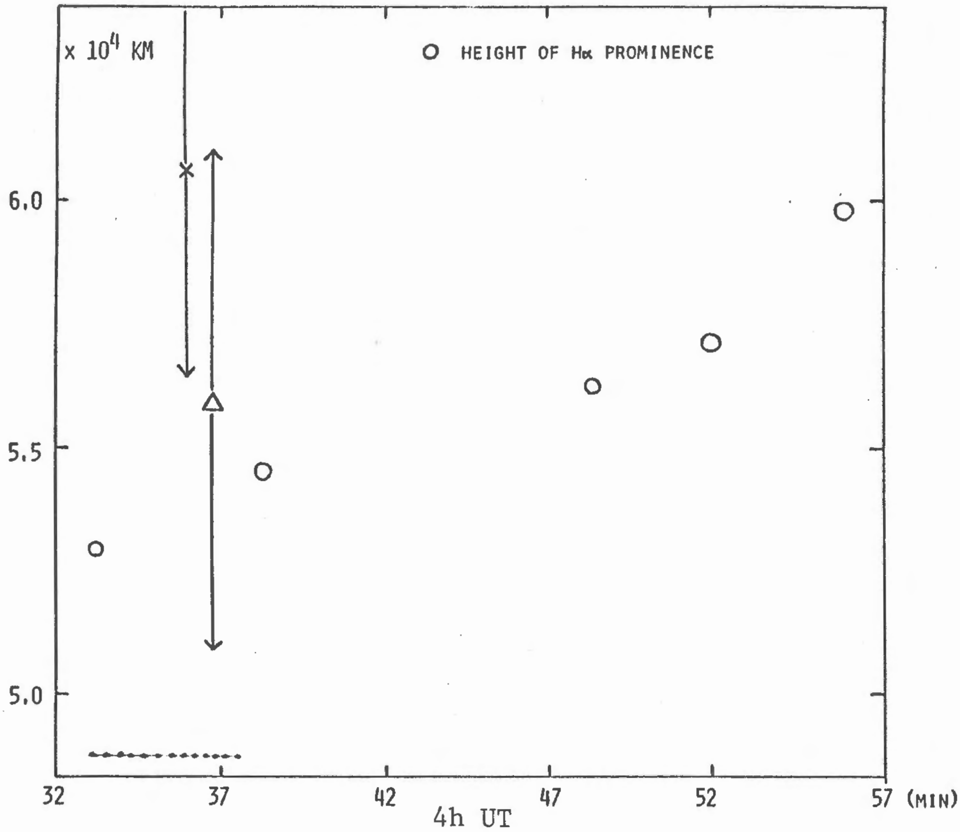


Figure 3. Progression of the Prominence in Height

x and Δ indiacates the height of core part of FeXIV 5303 and FeX 6374 condensations, respectively. Arrow indicates the size of the core part. Broken-line shows the eclipse time at Tuban.

where k, the Boltzmann constant, T the temperature, Λ the radiation cooling function (10^{22}erg/cm^3/sec), n the electron number density. Since $\tau \leqq 20$min, n may be larger than 7 10^9/cm^3 which is a typical value for a coronal condensation. The thermal conduction is less effective in cooling, because its mechanism gives the electron density, n, less than 7 10^8/cm^3. Such a feature is common in compact flares (Moore *et al.* 1980).

Hα prominence in this study increases the height with time as shown in Figure 3. This feature and the vertical temperature structure described above are common among the post-flare loops of the so-called two-ribbon flares. Kopp and Phneuman (1976) present a model which explains the features of the post-flare loops of two-ribbon flares. The phenomena in this study are small in scale when compared with the two-ribbon flares, but the Kopp and Pneuman mechanism seems to be applicable this case.

V. Acknowledgements:

The authors would like to thank Drs. Y. Nakai and K. Iwasaki and Mr. T. Asada of the Kwasan Observatory for instructing the operations at the PDS microdensitometer and the KIPS system. They also thank to Dr. H. Kurokawa of the Hida Observatory for offering his Hα filtergrams, taken with the DST at the eclipse time, at their disposal. They are much owed to Mr. Suratno, Aerospace Research Center of the National Institute of Aeronautics and space, Indonesia who was member of the eclipse operation at Tuban.

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Observation of the Contact Time and K corona at the Total Solar Eclipse of June 11, 1983 in Indonesia

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Abstract

The total solar eclipse of June 11, 1983 was observed in Mojokerto, Indonesia. Observation of contact times was made by the spectrophotometric method with a spectroscopic telescope which is composed of an objective prism of direct vision type and a Schmidt-Cassegrain telescope (f=225cm, D=10cm). Pictures of corona were taken with a refracting telescope (f=110cm, D=10cm) through a filter of effective wavelength of 6271Å and a half width of 98Å. The geodetic position of observing site was determined by Doppler observations of NNSS satellites with Magnavox MX 1502 receiver.

1. INTRODUCTION

The relative position of the Sun and the Moon is well determined in the direction of their relative motion from the observation of contact times on the central line. The perpendicular component of relative position can be determined more accurately when two observing sites are added at the places near the north and south limits of total solar eclipse.

We made observations in Mojokerto near Surabaya. Mojokerto is apart about 60 km southward from the central line of total solar eclipse, and was selected as the south observing site of the coorperation with Japanese Hydrographic Department (JHD). The team of JHD made observations of contact times at Kragan (north observing site) and Tuban (central observing site).

Two methods were planned to observe contact times. The first is cinematographic observation of flash spectra at the second and third contacts with an objective prism. Observation of flash spectra has been used to determine the contact time since Kristenson (1952), and is now a standard method. The method is well described by Kristenson (1952), Hiei and Faller (1967), Mori and Kubo (1971), and Kakuta and Iwadate (1976). The second is cinematographic observation of solar images of extreme limb through a narrow band filter. However, we could not put in practice the observation by this method because of the robbery of some instruments at Surabaya. The case of robbery is stated in section 2 together with the schedule in Indonesia. We tried to recover the loss of instruments as much as possible we could do on the site and in the limited period. Eventually, we could make observation of K corona instead of this second method according to the suggestion by Dr. E. Hiei.

The geodetic positions at four observing sites were determined by Doppler observations of NNSS satellites with Magnavox MX 1502 receiver. These sites are Mojokerto (International Latitude Observatory of Mizusawa (ILOM)), Tuban (JHD, and Kwasan and Hida Observatory of Kyoto University (KHO)), Kragan (JHD) and Cepu (Tokyo Astronomical Observatory (TAO), and Tohoku University).

Instrumentation and observation are described in section 3 and 4, respectively. Coronal structure is discussed in section 5.

2. SCHEDULE and ROBBERY of INSTRUMENTS

We arrived at Jakarta in the afternoon of May 9. At first, we heard from Dr. S. Saito the robbery of instruments bonded at the container yard in Surabaya. In Jakarta, we visited LIPI (Indonesian Institute of Sciences), LAPAN (Indonesian National Institute of Aeronautics and Space), Japanese Embassy and Marubeni Corporation for salutation and consultation. In the evening of May 11, we arrived at Surabaya. From May 12 through 16, we were engaged in managements of the customs clearance, the case of robbery, transportation of instruments to the observing site. On May 16, the customs clearance was finished. Equipments were inspected at the bonded warehouse of the Surabaya Customs and transported to the observing site (Mojokerto Factory of P.T. Ajinomoto Indonesia).

The case of robbery is summarized in the following. This case occured at the bonded warehouse of the Surabaya Customs during the process of customs clearance. Equipments of TAO, JHD, KHO and ILOM were shipped in three containers (two 20-feet containers and one 40-feet container) by Tokyo Maru Voy. No. 54 which departed Yokohama on March 4 and arrived at Surabaya on March 31. From April 4 through May 16, equipments were kept at the bonded warehouse of the Surabaya Customs. Our equipments were packed in 38 wooden boxes (net weight : 2.4 tons, gross weight : 4.4 tons, volume : 23.8 m^3). 32 boxes were put into the container No. ICSU-372460-9 (20 ft.). 6 boxes were put into the container No. TSKU-600116-1(40 ft.) together with equipments of TAO and JHD. On May 7, joint survey was carried out by Customs Authority, Port Authority, Official of EMKL (Sea Cargo Expedition) and Official of BLT (P.T. Bingtang Laut Timur), because it was found a few days before that some instruments were scattered around the containers. On May 16, we received the program report of joint survey dated on May 9. After the customs clearance, we examined the contents of the containers. At the same time, we asked P.T. Maskapai Asuransi "Indonesia" to make a survey report for insurance. On June 3, we received the survey report dated on May 16.

The conditions of robbery were as follows :

Container No. ICSU-372460-9 : Box No. L35 was opened and the contents were missed. In this box, were put 2 cases of pen-recorder charts, barograph in the box L32 and hygrothermograph in the box L33.

Container No. TSKU-600116-1 : Boxes No. L32 and No. L33 were broken and all the contents were missed. Broken boxes No. L32 and No. L33 are shown in figure 1.

Figure 1. Broken boxes at the bonded warehouse of the Surabaya Customs.

Missed equipments were collimator, controller of Nikon F2 motor drive camera, hygrothermometer, quartz-chronometer in the box No. L32, and short-wave receiver (main body, speaker, head receiver), radio receiver, mirror of 20 cm Cassegrain telescope in a parts-case in the box No. L33, and pulse camera (main body, power supply unit, controller, film magazine) and photographic films in the box No. 35. These are fundamental equipments for the observation.

After the observation, on June 17, we filed the claim for missed equipments of the total value ¥2,334,000.- to P.T. Samudera Indonesia. Mr. T. Yokokawa, the Consul-General of Surabaya, kindly sent a letter to ask the chief of customs of Surabaya to exert the influence for the speedy settlement of the case. Dr. E. Hiei, the chief of Japanese

Eclipse Party, wrote a letter to ask Prof. D.S. Sastrapradja of LIPI to convey our claim to the authorities concerned. On August 25, after returned to Japan, we received the claim amount of ¥2,334,000.- from P.T. "Samudera Indonesia".

We stayed at Mojokerto to carry out the observation from May 16 through June 14. Before the observation, from May 16 through June 10, we pursued the works such as set up of instruments, action tests of instruments and test observations. On June 11, the observation of solar eclipse was carried out. The equipments were disassembled and packed on June 12 and 13. On June 14, the equipments were delivered to the shipping company for the freight to Mizusawa. Sato and Kuji arrived at Tokyo on June 22 and June 20, respectively.

3. INSTRUMENTS

General instrumentation is shown in figure 2. In this figure, dotted lines show the parts which were planned initially but stolen at the bonded warehouse of the Surabaya Customs. Instruments with asterisk are the changed or supplemented ones on the site. Each part is explained in the following.

Spectroscopic telescope : This telescope consits of a camera telescope, an objective prism, a cine-camera and a step filter densitometer. The tube of the telescope can be rotated to adjust the direction of dispersion. The camera telescope is a Schmidt-Cassegrain type of D=10 cm and f=225 cm. The objective prism is a direct vision type of three prisms (BK7 and F2) which has a direct vision at the wavelength of 4861Å (H_β) and dispersion 80 Å/mm with the camera telescope (f=225 cm). The cine camera was Automax Pulse Camera which takes 10 frames per second with shutter speed 1/60 seconds on half size of 35 mm film. However, Nikon motor drive camera for the direct image telescope was used instead of Automax Pulse Camera. The step filter densitometer consists of a collimator with D=9 cm and f=100 cm, a slit and a step filter which has 6 steps of densities from 0 through 2.5. Density scale through objective prism could not be taken by this densitometer because the collimator was missed.

Direct image telescope : The telescope is a Cassegrain type with a main mirror of D=20 cm and a synthesized focal length of 400 cm. It was planned that direct images through narrow band filter were taken by a motor drive camera. The motor drive camera is Nikon F2 which can take 750 frames with speed of 3.6 frames per second on 35 mm film. The narrow band filter has a half width 98Å and effective wave length 6271Å. However, we could not put into practice the observation by this telescope, because the main mirror was missed and the motor drive camera was used for the spectroscopic telescope.

10 cm refracting telescope : Lens of D=10 cm and f=110 cm was attached to the tube of the Cassegrain telescope in place of mirrors for

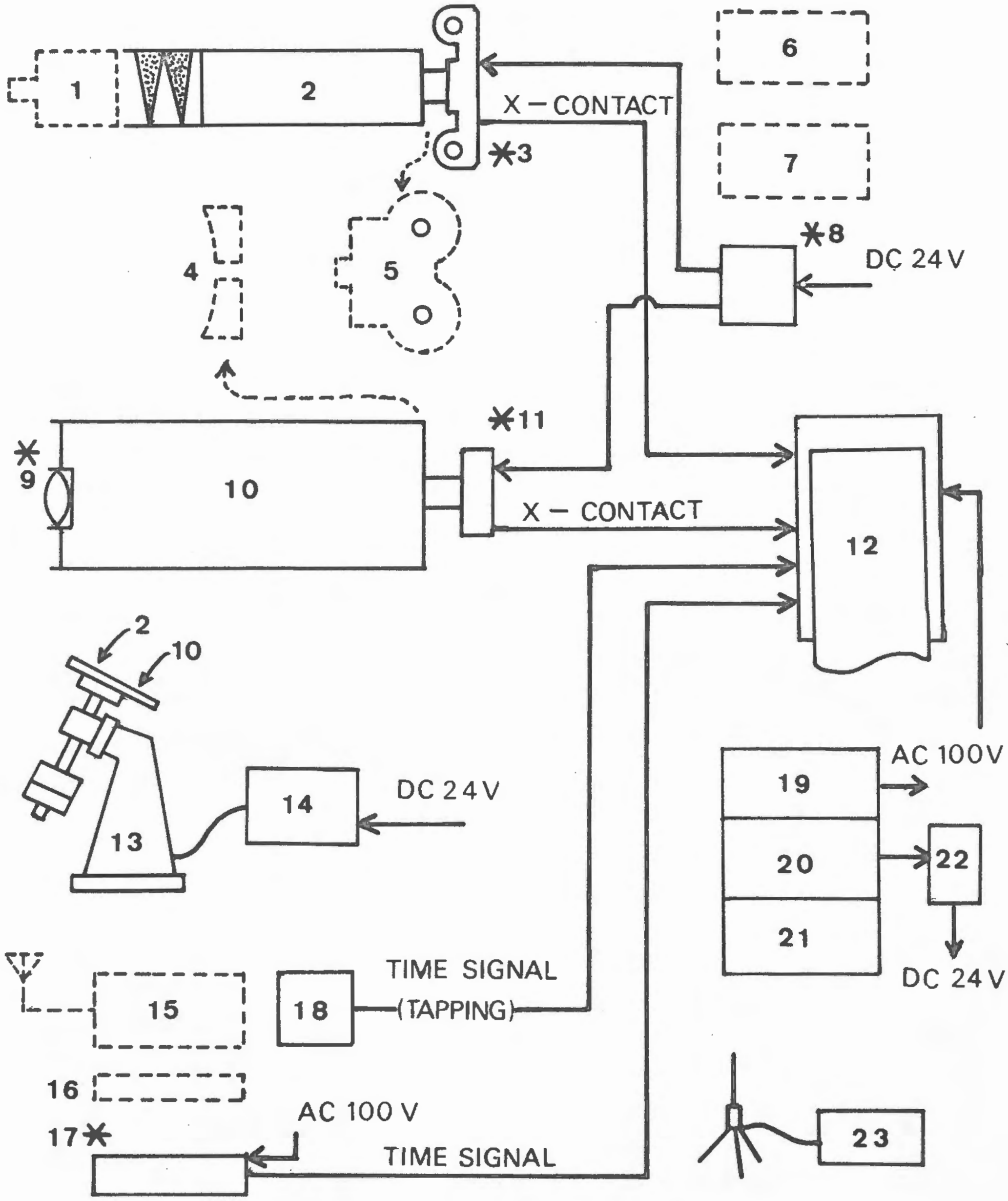
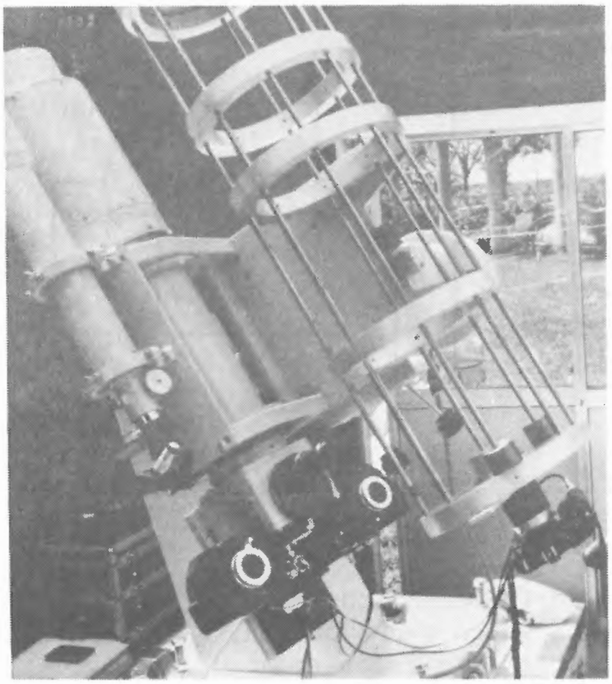


Figure 2. Block diagram of general instrumentation.
Broken lines show the instruments which were stolen. Instruments with asterisk are the changed or supplemented ones. 1. collimator; 2. spectroscopic telescope; 3. Nikon F2 Motor Drive Camera (750-Exposure); 4. mirror of D=20cm; 5. Automax Pulse Camera; 6. controller of Pulse Camera; 7. Shutter controller; 8. shutter switch box; 9. 10cm lens; 10. tube of 20cm Cassegrain telescope; 11. Nikon FE Motor Drive Camera; 12. pen recorder; 13. equatorial mounting; 14. controller of equatorial; 15. shortwave receiver; 16. and 17. quartz chronometer; 18. portable radio; 19. inverter; 20. DC inverter; 21. transformer; 22. battery; 23. Doppler receiver (Magnavox MX 1502).

two purposes. The first is to secure the density scale. Solar images were taken through combinations of neutral and narrow band filters. The second is to make observation of K corona. Images of corona were taken through a narrow band filter of a half width 98Å and effective wavelength 6271Å by a Nikon FE motor drive camera of regular type.

Equatorial mounting : The equatorial is a German-type mounting. The two telescopes mentioned above were installed on this mounting. The drive is made by pulse motors with a quartz oscillator. We can use the power supplies AC 100V (50Hz/60Hz) and DC 12V. The tracking can be made in mean solar and sidereal rates. The clamp of axes is made manually by handles at the eyepiece side. Guiding and setting drives in right ascension and declination are made electrically from the hand box in rates of 3"/sec and 3'/sec, respectively. The spectroscopic telescope and the equatorial mounting were manufactured by Nishimura Factory Co., Ltd. The telescopes in the observing house are shown in figure 3.



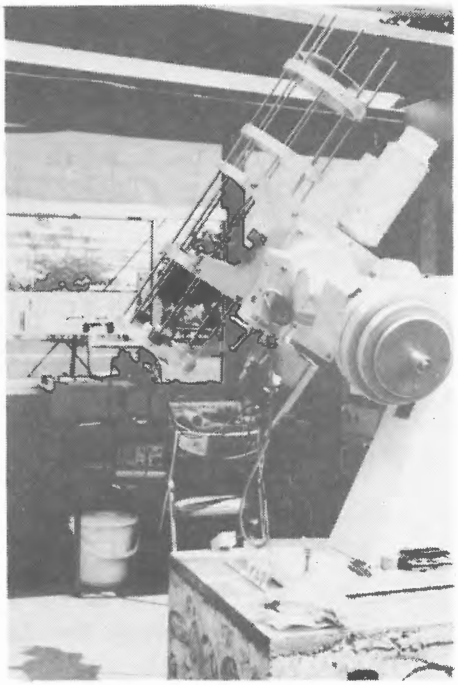


Figure 3. Telescopes in the observing house.

Pen recorder with six pens of Watanabe Sokki Co., Ltd. was used to record the shutter signals of cameras and time signals of chronometer. Short wave receiver of Anritsu Co., Ltd. was prepared to receive the time signal, but was stolen. We bought a regular radio receiver (SONY) in Surabaya. The time signal received by this receiver could not be recorded directly on the pen recorder because of radio noise. We carried out the ear and tapping method by hearing the tone of time signal of JJY to rectify the chronometer. The quartz chronometer prepared was also stolen. We assembled a set of quartz chronometer with electric parts and a unit of quartz oscillator on the site. The electric power supply is 220V/50Hz in Indonesia. We prepared AC transformer, AC-DC and DC-AC inverters, and batteries. We could use, however, 100V/50Hz power supply from the factory of P.T. Ajinomoto Indonesia.

We prepared a prefabricated observing house of which roof can be opened for observations. This was useful to keep instruments in it, but heavy and big for the transportation. Figure 4 shows the external view of the observing house and the antenna of Doppler receiver.

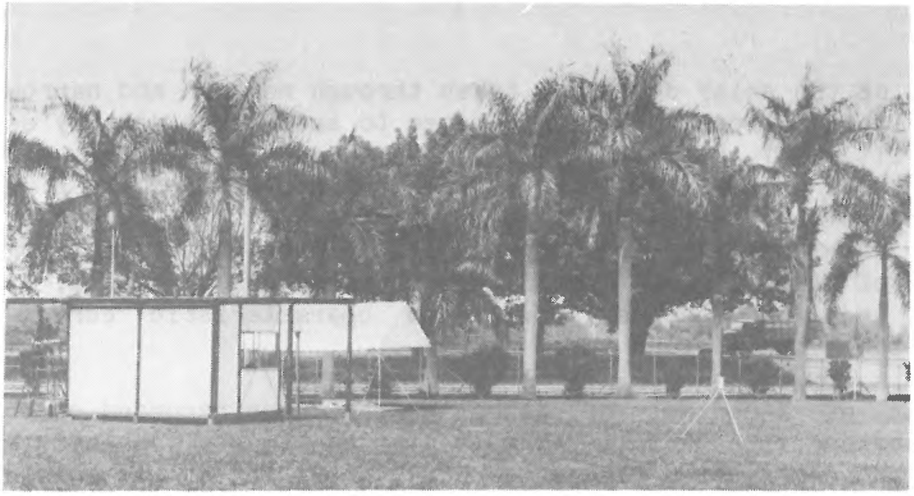


Figure 4. Prefabricated observing house, where telescopes and electric instruments were installed and operated. Antenna of Doppler receiver is seen in the right portion.

4. OBSERVATION

We observed the second and third contacts with the spectroscopic telescope. Images of K corona were taken during the totality with the 10 cm telescope. Thin cloud remained in the early morning of June 11. However, it was clear at the time of total eclipse. Those observations were carried out according to the time schedule shown in table 1.

Pictures of flash spectrum and corona were taken on the film of Kodak Technical Pan 2415 which is rather sensitive and has a sensitivity up to H_α and a very fine grain. The observed films were developed at Far East Laboratories, Ltd. (Yokohama) by using the MQ developer.

Table 1. Time Schedule of Observation.

Time (UTC)	Event	Action of Instruments
2h 59m 0.95s	1st contact	
4 33 35		pen-recorder : start
4 33 40		flash spectrum : start
4 34 10.60	2nd contact	
4 34 40		flash spectrum : stop
4 35 50		corona : start
4 36 08.65	maximum	
4 36 52		corona : stop
4 37 40		flash spectrum : start
4 38 6.83	3rd contact	
4 38 42		flash spectrum : stop
4 39 04		pen-recorder : stop
6 16 7.14	4-th contact	

Images of the solar disk were taken through neutral and narrow band filters a little before the solar eclipse to secure the density scales. Densities 4.11, 4.41, 4.71, 5.11, 5.41, 6.11 and 6.41 were made by combinations of neutral filters. Narrow band filters are a red one (effective wavelength 6271Å and a half width 98Å) and a green one (effective wavelength 5336Å and a half width 74Å). Images for each combination of filters were taken with shutter speeds of camera, 1, 1/8, 1/30, 1/125 and 1/500 seconds. Thus, the characteristic curves were secured at those two wavelengths.

Signals of X-contact of Nikon camera were recorded on the pen recorder together with the time signals of the quartz chronometer to determine the observation time of each picture. The quartz chronometer was rectified by the time signal of JJY.

Geodetic positions at four sites were determined by Doppler observations of NNSS satellites with Magnavox MX 1502 receiver. The reduced positions are shown in table 2. The positions are in the WGS-72 system. The height is the value measured from the reference ellipsoid. In table 2, the position at Cepu shows the value at the antenna of the Doppler receiver. The positions at the other sites are reduced to the values at the telescopes of ILOM and JHD.

Table 2. Geodetic Positions of Observing Sites.

Site	Latitude	Longitude (E)	Height
Mojokerto	-7° 27' 01".35	112° 26' 39".06	+77.5m
Cepu	-7 07 52.35	111 35 25.91	+92.1
Tuban	-6 54 11.29	112 02 54.24	+61.3
Kragan	-6 42 19.82	111 36 26.76	+46.8

We took 223 and 219 pictures of flash spectrum around the 2nd and 3rd contacts, respectively. Flash spectra near the 2nd and 3rd contacts are shown in figure 5 and 6, respectively.

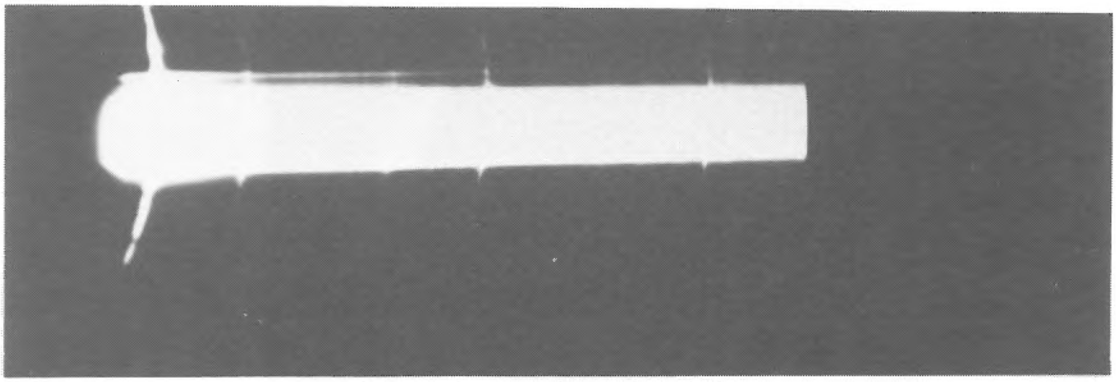


Figure 5. Flash spectrum at the 2nd contact (4h 34m 10s UTC).

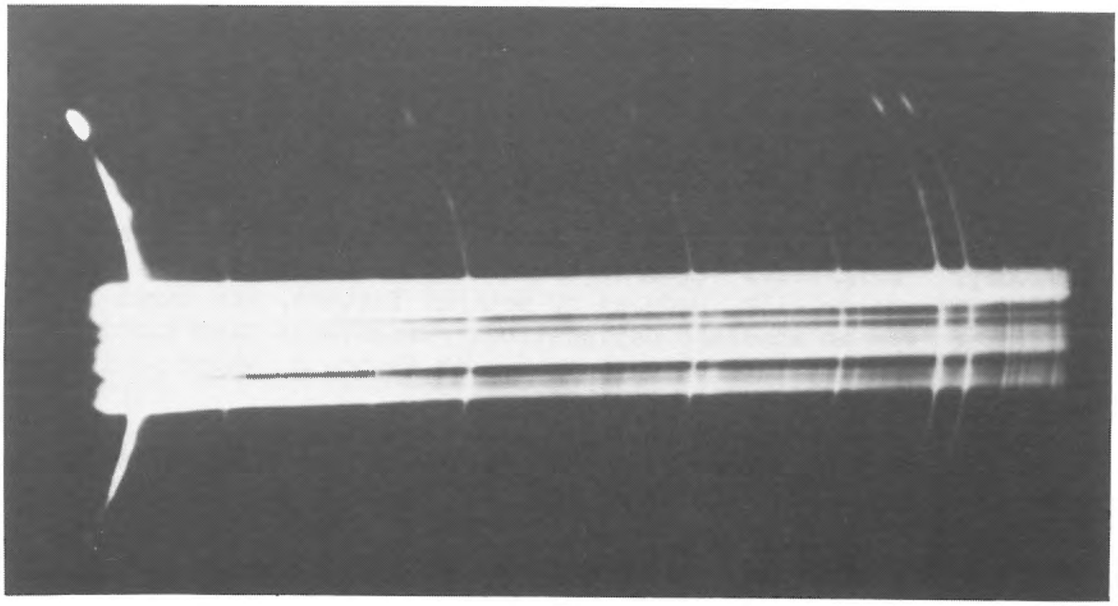


Figure 6. Flash spectrum at the 3rd contact (4h 38m 07s UTC).

5. CORONAL STRUCTURE

Pictures of K corona were taken during the totality through a narrow band filter of 6271Å (a half width 98Å). With the exposure time of 1 second, 53 pictures were secured from 4h 35m 50s through 4h 36m 52s UTC. A picture of K corona is shown in figure 7.

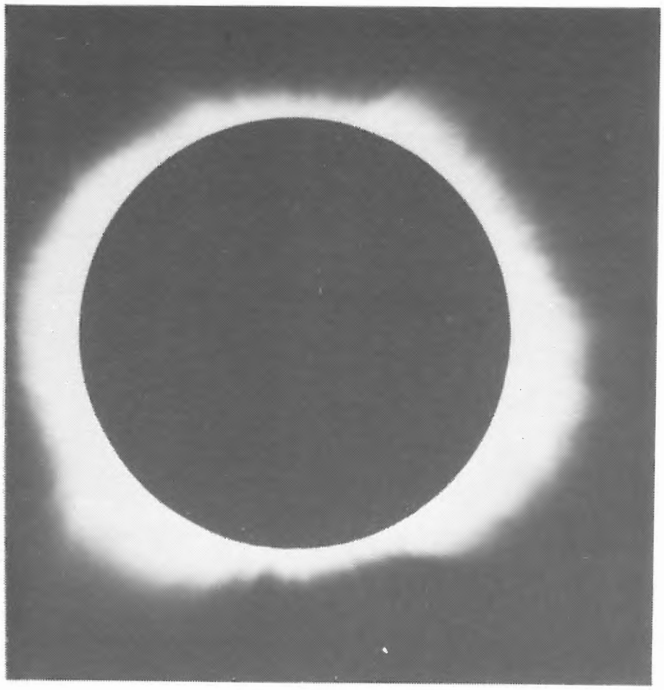


Figure 7. A picture of K corona (4h 36m 01s UTC) taken through a narrow band filter of 6271Å (band width 98Å). The north and east are the top and left, respectively, in the figure.

The films were traced with a microphotometer at Tokyo Astronomical Observatory. Brightness distribution of the corona was derived from tracings. The solar disk, reduced by neutral filters, was taken before the eclipse for an absolute calibration. Brightness distribution with height at the north polar region is shown in figure 8, which is in good agreement with Koutchmy's result (1984).

Intensity and width of a north polar ray were measured along the height. Intensity between the ray was assumed to be as a background and a total width at half intensity was measured at different heights. The width on the average is about 10 arc seconds, which is almost the same as the measurements by van de Hulst (1950).

Electron density for the ray is derived as shown in figure 8, under the assumption that the length in line of sight of the ray is the same as its width. The derived electron density is about 5 times larger in the ray than Saito's result (1965).

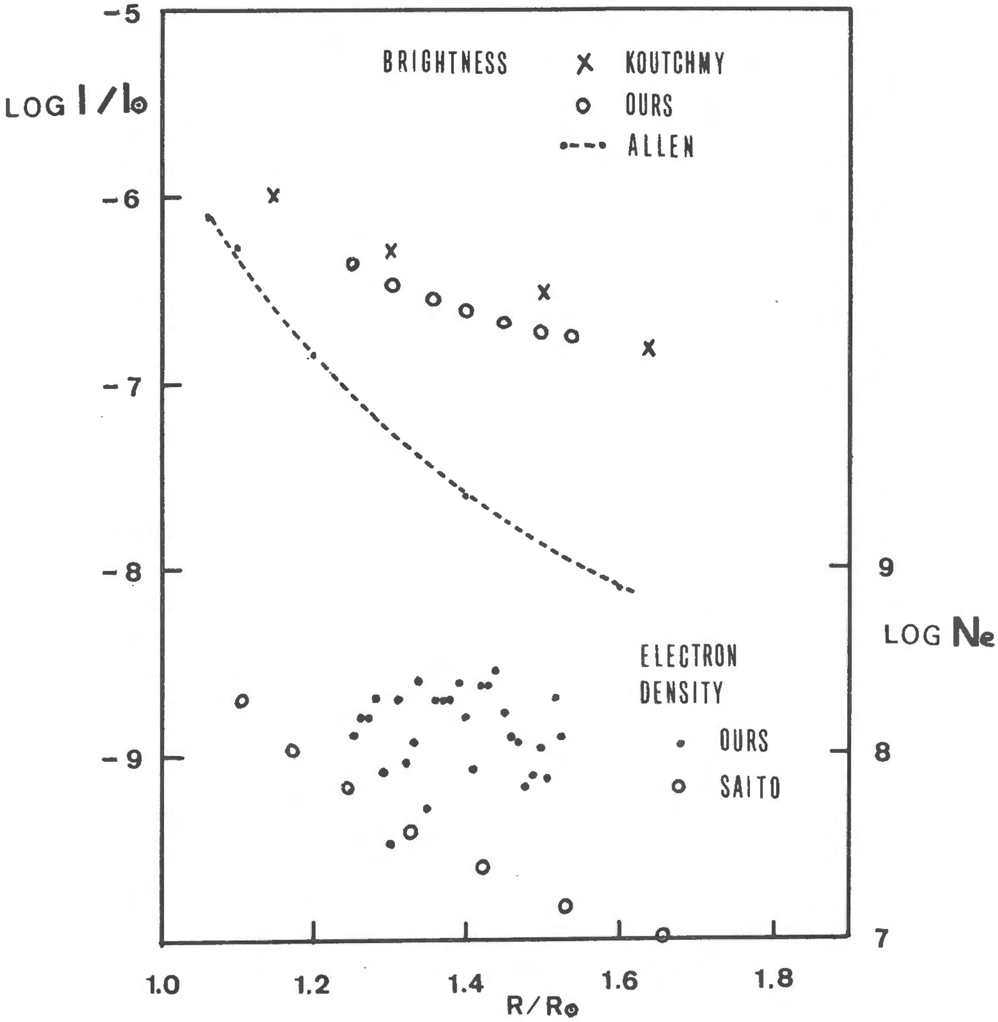


Figure 8. Brightness distribution of the corona at north polar region (above), and derived electron density (down) with height in unit of solar radius. The left ordinate is expressed in unit of the continuum brightness at the disk center at 6270Å. The cross in brightness is measured by Koutchmy and Nitschelm (1984), and "Allen" means smoothed coronal brightness at pole of minimum phase in K corona (Allen, 1972). The circle in electron density is derived by Saito (1965).

The flattening index, ε , defined by H. Ludendorff (van de Hulst, 1953) is computed by using the iso-intensity curves derived from the film. The indices are in agreement with Koutchmy's result (1984), as shown in figure 9.

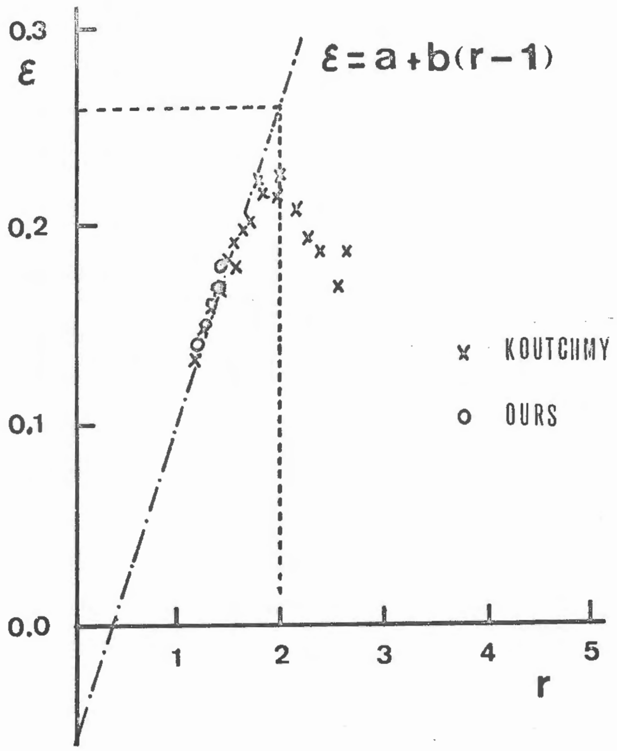


Figure 9. Flattening index ε versus height. ε is defined as $\varepsilon = R_{eq}/R_{pol} - 1$. The cross (Koutchmy and Nitschelm, 1984), circle (ours). Our results are expressed by a straight line, $\varepsilon = 0.105 + 0.167\ (r-1)$, where $r = R_{eq}/R_{\odot}$.

The flattening indices at small r are expressed by a straight line as $\varepsilon = a + b(r-1)$, where $r = R_{eq}/R_{\odot}$. The value of a+b means the flattening of the corona at r=2. From the results shown in figure 9, we obtained an expression $\varepsilon = 0.105 + 0.167\ (r-1)$. a+b is found to be 0.27, which is almost same as Koutchmy's (1984) value of 0.26. It is found that the value of 0.27 at the estimated phase -0.35 is well fitted to the relation of a+b against the phase in the solar cycle, which is shown in the figure 9 of van de Hulst (1953).

ACKNOWLEDGEMENT

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OBSERVATION OF CONTACT TIMES OF 1983 TOTAL SOLAR ECLIPSE IN INDONESIA

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A joint team of the Hydrographic Department of Japan and the Aerospace Research Center of LAPAN (National Institute of Aeronautics and Space), Indonesia made observations of the total solar eclipse which occurred on June 11, 1983. We observed at two stations in east Jawa, the one at Tuban which locates near the central line of totality and the other at Kragan which locates on the halfway to the northern limit of totality. The second and third contacts were observed with spectrotelescopes and flash spectra were recorded by 16-mm cameras. The standard signals on short radiowaves were used to calibrate the clocks on the observing sites. The measurements of the films and reductions of data are being performed in the Hydrographic Department of Japan to obtain the relative positions between the sun and moon. These data will be compared with the astronomical ephemeris in order to check and improve it.

1. INTRODUCTION

The Hydrographic Department of Japan (JHD) has been publishing the astronomical ephemeris (Japanese Ephemeris) annually since 1943. Various astronomical observations have been conducted by JHD to examine the dynamical theory of the planetary system and to improve the constants adopted in the theory. The position of the sun is a fundamental quantity in the theory but is difficult to measure precisely because the brightness of the sun is so magnificient. In the case of total solar eclipse, the sun is located in the same direction with the moon and the brightness of the sun is lost. Thus, total solar eclipses give us good chances to measure the relative positions between the sun and moon precisely enough to check and improve the ephemeris.

The observations of the solar eclipses carried out by the Hydrographic Department of Japan within these 30 years are listed in Table 1. The latest observation which was conducted in Indonesia on June 11, 1983 is described in this report.

2. METHOD OF OBSERVATION

Table 1 Solar eclipse observation performed by JHD

Date				Observation Site
1948	May	9	A	Rebun-to (Japan)
1955	June	20	T	Vietnam
1958	Apr.	19	A	Aoga-shima, Takara-jima and Amami O-shima (Japan)
1958	Oct.	12	T	Suvorov (Tokelau)
1962	Feb.	5	T	Lae (Papua New Guinea)
1963	July	20	T	Abashiri (Japan)
1965	May	30	T	Manuae (Cook Is.)
1970	Mar.	7	T	Mexico
1973	June	30	T	Mauritania
1976	Oct.	23	T	Australia
1980	Feb.	16	T	Kenya
1983	June	11	T	Indonesia

A : Annular eclipse, T : Total eclipse

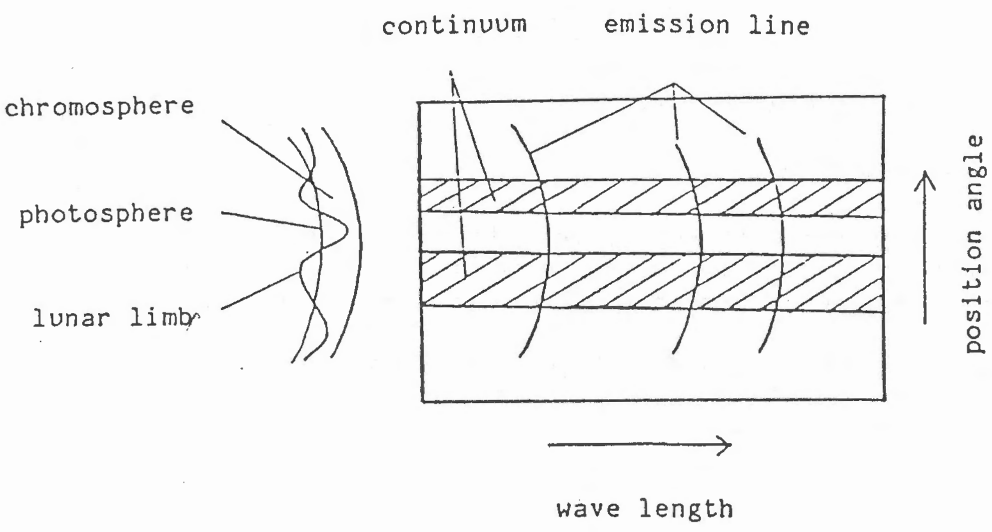

Figure 1 Flash spectrum

The precise observation of times of the first and fourth contacts are difficult because of the brightness of the sun like usual circumstances. Only the times of the second and third contacts can be observed precisely. At the third contact, the situations are essentially the same except that the time sequence is reversed.

In a total solar eclipse, the sun becomes a thin arc just before the totality begins. Then the arc shrinks from its both ends and at last the light of the sun diminishes. But the decrease of sun's light doesn't occur uniformly along the arc because of the rugged surface of the moon. The arc is cut into pieces corresponding to the mountains and valleys of the moon's limb. To obtain the relation between the centers of the sun and moon, the correction of the ruggedness of the moon's limb is essential.

Another problem which deteriorates the quality of observation is the existence of the chromosphere which lies just outside of the photosphere and emits many emission lines. The light from the chromosphere contaminates that of the photosphere and affects the measurements of contact times. So, we must avoid these emission lines coming from the chromosphere which are considered to contain invaluable information for solar physics researchers.

To solve these problems, we adopted a method to record the light of the sun dispersed into a spectrum with a prism by a 16-mm movie camera. Figure 1 shows an example of the spectrum. There the continuum light comes from some parts of photosphere which are seen through valleys of the moon, while the emission lines from the chromosphere appear as many arcs similar to the shape of the sun. The emission lines remains for several seconds after the continuum light diminishes. Then the spectrum is called a flash spectrum. We record the variation of this spectrum in a time sequence by the movie camera.

3. INSTRUMENTATION

Our equipments to record the flash spectrum consist of a prism, a telescope, a 16-mm movie camera, a timing device and an equatorial mounting. Figure 2 shows the schematic diagram of the equipments.

The prism is an objective direct version type of 60mm x 60mm in size which is composed of a SF2 prism placed between two BK7 prisms. The aperture and focal length of the telescope lens are 80mm and 1200mm, respectively. This optical system is designed to pass the light of 486nm wavelength(H_β) straight. The dispersion of spectrum is 7nm/mm at 486nm. The movie camera is a Bolex H 16's type, which is driven with an electric motor. In order to make the direction of dispersion perpendicular to the arc image of the sun, the telescope tube is designed to be rotated around the optical axis. This is assured by holding the tube with bearings on the mounting. Thus, we can adjust the position angle of the telescope very rapidly between the second and third contacts to prepare for the observation of the third contact.

Time signals are generated by a crystal oscillator. By these signals, a

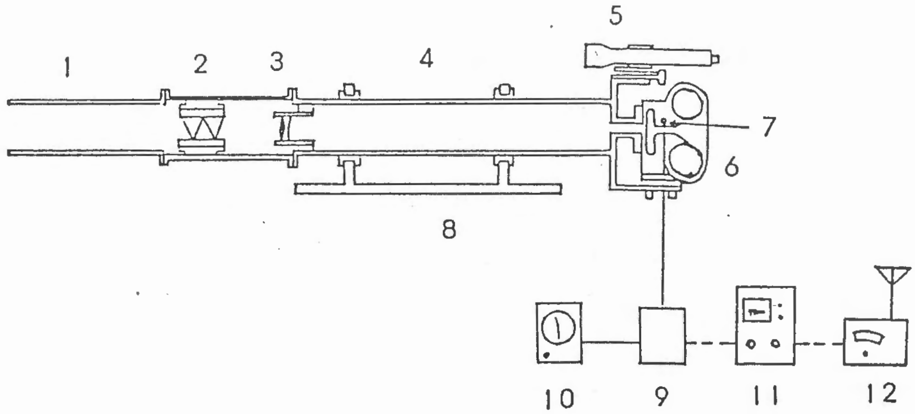

Figure 2 Observing facilities

1. hood
2. prism
3. lense
4. body
5. guide telescope
6. 16mm movie camera
7. emitting diode for time-marking
8. mounting attachment
9. time-marker controller
10. quartz oscillator
11. synchroscope for clock comparison
12. short wave radio reciever

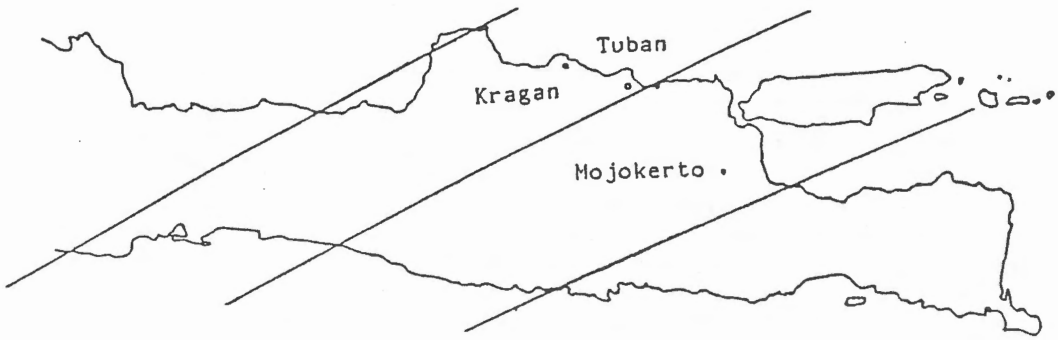

Figure 3 Path of total phase at Java island

light-emitting diode attached in the 16-mm movie camera is stimulated to register a time mark on the edge of a film. Time marks are recorded every 1/10 sec, 1 sec, 10 sec, 1 min and 1 hour which are differenciated by their lengths. The crystal oscillator is calibrated to the standard time signals broadcasted on the short wave by means of a synchroscope.

4. OBSERVATION

Two members of Japanese side visited Indonesia from May 9 to June 20,1983. A member from Indonesia joined them throughout this period to set up and adjust the equipments, to make observations and to remove the equipments.

If the observation site is near the central line of totality, the observed position angles of the second and third contacts will be about 90° and 270°, respectively. They approarch to 0° or 180° according as the location of the observation site approaches to the northern or southern limit of the totality We obtain two measurements of different position angles by observations of the second and third contacts at one site. The results obtained from an observation site located near the central line of totality are much suitable to determine the relation between the centers of the sun and moon in the east-west direction but they are not so effective to determine the relation in the north-south direction. On the contrary, the results from observation site near the northern or southern limits are efficient to determine the relation in the north-south direction. The Hydrographic Department of Japan and LAPAN of Indonesia located two observation sites in Indonesia, the one at Tuban and the other at Kragan (Figure 3). The International Latitude Observatory of Mizusawa (ILOM) settled a observation site at Mojokerto and they conducted a similar observation. Combining these results obtained at three sites, we can determine the relative positions between the sun and moon at the time of eclipse precisely in both directions, in the right ascension and declination.

To compare the results with the predictions from the ephemeris, we must know the precise location of the observation site on the surface of the Earth. We used a satellite geoceiver MX1502 of ILOM to obtain three dimensional positions. The observations of navigation satellites were conducted at Tuban and Kragan for about two and one days, respectively. The data reduction was performed by the computer program named MAGNET and the position of the receiving antennas were determined. The position of the telescope which was located about 10m apart from the receiving antenna at both sites was connected by the survey with a metal tape and a theodolite. The true aimuth was determined by the transit observation of the sun. The geodetic coordinates of cross points of axes of telescopes at Tuban and Kragan are listed in Table 2.

The local prediction of the eclipse was calculated for each site. Then the telescopes were adjusted and the observing plans were made according to these predictions.

The observations of the second and third contacts were performed by taking a 16-mm movie film each time for the duration of about a minute whose center was located near the predicted times of contacts at their centers. In order

Table 2 Geodetic coordinates of observation sites

Site	Latitude	Longitude	Height
Tuban	− 6°54′11.″29	112°02′54.″24	61.3 m
Kragan	− 6°42′19.″82	111°36′26.″76	46.8 m

The height is measured from the reference ellipsoid WGS-72, whose characteristics are a = 6378135m and f = 1/298.26.

to obtain the characteristic curves of the films, that is, the relation between the density of the film and the intensity of light, additional shots were recorded within a few hours after the totality. In this case, the hood in Figure 1 was replaced by a slit and a collimation lens to make the light into the prism parallel. The intensity of light was changed with various orders of magnitude by the combinations of the width of the slit and the insertion of one of several neutral density filters in front of the 16-mm camera to make a calibration of density-intensity relationship.

The weather at the time of totality was good at Kragan with a very thin cloud which didn't seem to affect the observation. But a block of rapidly moving clouds at Tuban prevented from observing the second contact and the third contact was observed through a thin cloud that deteriorated the quality of data to some extent. We will describe this problem in the next section.

5. DATA REDUCTION

The intensity of the films are measured with a microphotometer at Tokyo Astronomical Observatory. We adopted a wavelength of 461.5nm as the wavelength to be measured, where the emission lines of chromosphere are sufficiently weak. We scan along a straight line perpendicular to the direction of dispersion with a rectangular slit of 100μm x 20μm. The length of 100μm in the direction of dispersion corresponds to the wavelength width of 0.7nm and the width of 20μm corresponds to 0.°2 of the moon's limb as the diameters of the sun and moon are about 12mm on the films. Since the starting point of the scan in a frame is arbitrary, the position angle must be identified by means of the density profile of prominent valleys and mountains of the moon's limb. Then the density variation at a position angle can be traced from one frame to another.

The density is transformed into the intensity of light by using the characteristic curve. The sun is a gaseous sphere and the intensity of light along the radial direction at the limb decreases continuously. So, we must define the sun's limb with a specific intensity of light in order to determine the contact time. We choose the inflection point of the characteristic curve to define the sun's limb to make the measurements consistently at any position angle. The contact time at a position angle is obtained by analyzing the data of a few tens of successive frames.

According as the measured position angle becomes apart from the center of the film, the background level of the intensity increases rapidly because the bright light from the central portion of sun's arc is scattered in the optics. Therefore the measurements by this method is limited within the range of about 20° of position angle at each contact.

The measurements are influenced by the atmospheric disturbances, the resolution power of the optics, the irradiation of the emulsion and the finiteness of the slit of the microphotometer. If the observations are made under clear skies, these effects can be estimated or are negligible. However, if the observations are made through clouds like that of the third contact at Tuban, the intensity of light fluctuates and the profiles of the mountains and valleys of the moon's limb tend to be leveled. We are trying to analyze these effects so that we will not suffer from any systematic error.

The corrections for the ruggedness of moon's limb are obtained from the Watts' charts(Watts, 1963). As the charts are made every 0°.2 in position angle, the corrections are obtained with that interval.

The relative positions of centers of the sun and moon are calculated from these data using the geometric relations and the relative movement between the sun and moon obtained from the ephemeris. The details of these expressions are found in the paper of Mori and Kubo (1971). The precision of determining the relative positions of the sun and moon reaches 0".01 in the direction of the position angle and 0".1 in the direction perpendicular to it. Combining our data obtained at Tuban and Kragan with the data observed at Mojokerto by ILOM, the precision of both directions, in the right ascension and declination, will become 0".01. The data reduction is still proceeding and the final results will be published in the future.

ACKNOWLEDGEMENTS

The selection of observation sites, the negociations with the local public offices and the preparations of facilities at the sites were done by Mr. Manurung of LAPAN. The observation site at Tuban was constructed by the cooperation with Drs. Saito, Funakoshi and Suematsu from Kyoto University and Mr. Suratno of LAPAN. Mr. Ooe of Tokyo Astronomical Observatory helped us in using the microphotometer. We are grateful not only to the people mentioned above but also to all people concerned, with whose supports and cooperations our observations became possible.

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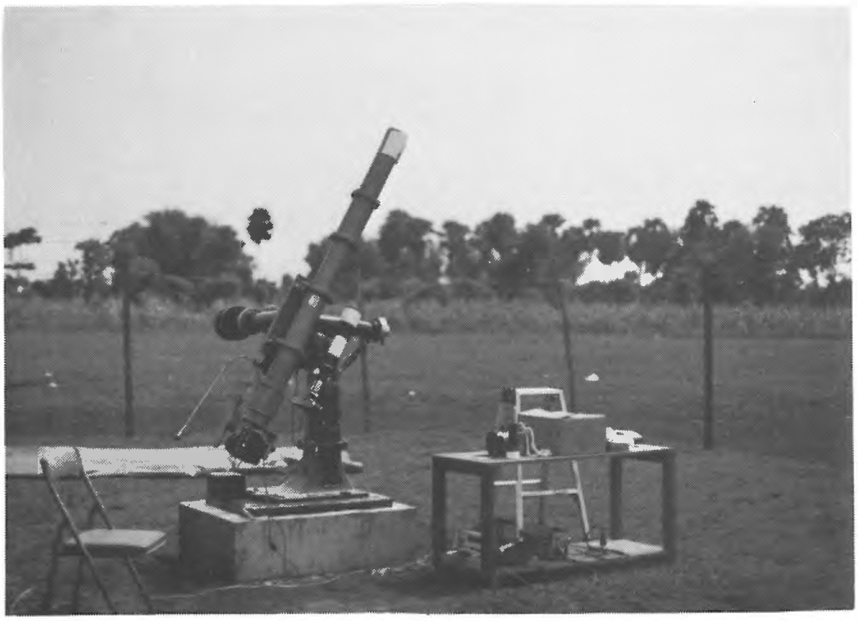
(top)

Kragan Site

(right)

Telescope at Kragan Site

Tuban Site



Telescope at Tuban Site

16mm movie camera

Clock comparison system

THE OBSERVATION OF TOTAL SOLAR ECLIPSE ON 11 JUNE 1983 BY USING C-5 & C-8 TELESCOPES AT MENTUL HILL, CEPU - CENTRAL JAVA - INDONESIA

by
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ABSTRACT. Optical observation of 1983 solar eclipse observation conducted by the Aerospace Research Center of Lapan made at the location on a hill of Mentul, Central Java(111° 35' 26" E ; 7 07' 52" S). The equipment used are Celestron 5 and 8inches (C-5 and C-8). The aimed targets were the determination of contact time and coronal structure from ellipticity or flattening index. The determination of contact time was made by using photographs taken with one frame per second before, the moment and after the 1st, 2nd, 3rd and 4th contacts. The times of the second and the third contacts can also be determined by solving the movement of the moon covering the sun.

1. INTRODUCTION

The strong contrast in intensity of the sun light is the serious problem on the solar eclipse observation, by visual and photography as well. For the purpose of photography an additional neutral filter in front of the objective of the telescope is needed. Before the second contact time and after the third contact time, a neutral filter, N.D.5, is used in order to reduce the intensity of sunlight to 10^{-5}. We obtained 744 frames of negative films. The contact times determined by two methods : visual and, photographic method. The coronal structure was determined from the several negative films taken by C-5 and C-8 in exposure times variated from 1/60 to 8 seconds. the negative films obtained were traced by a microdensitometer at the Tokyo Astronomical Observatory.

2. EQUIPMENT AND OBSERVATION

For the purpose of the aimed photography, we have used the two Celestron telescopes, which are of the type Schmidt-Cassegrain telescopes, are shown in Table 1.

Table 1 Characteristics of Telescope

	C-5	C-8
Diameter	125 mm	200 mm
Focal length	1250 mm	2000 mm
F - ratio	f/10	f/10
resolution	0.9 arc second	0.6 arc second

N.D.5 neutral filter was put in front of the telescope when part of the solar disk was seen. A camera of Cannon F-1 type was attached to each telescope. The camera system and its electronic control is shown in Figure 1. The film used is technical Kodak Pan Film 2415 and Kodak Plus X.

During 1983 total solar eclipse in Cepu, the films obtained are 6 magazins of black and white film consisted of 100 frame (600 figures) and 4 black and white film rolls of 36 exposures so the total obtained photographs are 744 pictures. Some pictures are seen on Figures.

3. DETERMINATION OF CONTACT TIMES

To determine the contact times, we used two telescope, C-5 and C-8, attached with the cameras of Cannon F-1. The schedule of making photograph was made as follows:

a. First contact.
From 02h 56m 30s to 02h 58m 09s U.T, when the edge of

the moon was near the limb of the Sun, the photograph was taken by using C-8 with N.D.5. The number of photos taken are 100 frames during 100 second.

b. Travelling of the moon covering the sun.
The movement of the moon covering the sun was photographed with one frame per minute. At this moment C-5 and C-8 was used and 172 frames were obtained.

c. Second contact.
From 04h 30m 20s to 04h 31m 59s U.T. The event was photographed by using C-8 without a filter. The obtained negative films were 100 frames during 100 seconds or one frame per second.

d. Coronal structure.
In the total solar eclipse, the photograph was done by using C-5 and C-8 without a filter. For this moment, the exposure time was varied as:

- inner corona ; exposure time : 1/60 to 1/8 second
- middle corona ; exposure time : 1/8 to 1 second
- outer corona ; exposure time : 1 to 8 seconds.

During this observation, 100 frames of negative films were taken.

e. Third contact.
Just a moment before and after the third contact, from 4h35m30s to 4h37m09s, the photographs were taken by using C-8 without a filter. The negative films obtained are 100 frames during 100 seconds or one frame per second.

f. Movement of moon leaving the solar disc.
After the third contact, the moon swept the solar disc in one hour. During this event, the photographs were taken by using C-5 and C-8, and the number of negative film was 172 frames in nearly one hour.

g. Fourth contact.
From 6h13m00s to 6h14m39s, a moment before and after the fouth contact, the C-8 provided with N.D.5. was used, and 100 frames of negative film during 100 second or one frame per second are taken.

The time calibration was derived from W.W.V.H. and the

Japanese team's Clock, which had been fixed also to W.W.V.H. We used the digital clock FX-7100 which has hour, minute and second, having two desimals.

The first and fourth contact times were determined from the series of obtained negative films, while the second and the third contact times were derived from diamond ring and Baily beads, the accuracy of contact times for all measurement was ± one second.

The determination of times of the second and the third contacts is dereved in the method as follows:

a. Visual method.
   This method can be done by observing the diamond ring and Baily beads through the Celestron telescope, C-8.

b. Photographic metod: Disapperance or reappearance of one Baily bead is determined from the photographs taken one frame per second.

The contact times derived from the method discussed is shown on table 2. On this table the contact times determined by Fiala (1982) and Japanese team (1983) is also indicated.

Table 2. The 1983 solar eclipse contact time

	1st contact	2nd contact	3rd contact	4th contact
	h m s	h m s	h m s	h m s
visual	-	4 31 06	4 36 10	-
photographic	2 56 43	4 41 08	4 36 10	6 13 54
Fiala	2 57 10.4	4 31 05.2	4 36 17.7	6 13 51.8
Japanese	2 57 16.3	4 31 11.9	4 36 19.7	6 13 53.4

4. FLATTENING INDEX

The intensity distribution as a function of radial distances gives isophote curves of coronal structure which is either circular or less circular. The overall structure of the corona is described by ellipticity or flattening index, ε, defined by Ludendorff (1953) as

$$\varepsilon = a + b(r-1)$$

where $r = R_{eq}/R_{pol}$ and R_{eq} and R_{pol} are average radial distances of a certain isophte curve lines in the region of ±20° 30'around the equatorial and the polar regions.

The ellipticity or flattening index of coronal structure determined by LAPAN's team, and also the flattening indexes of Koutchmy (1984), and of Sato and Kuji (1985) are shown in Fig. 13.

5. DISCUSSION

Although the weather condition wasn't clear during the observation, the observational result on certain time had obtained good solar corona as shown in Figures 2-12.

Based on the photographic and visual observation methods, the contact times derived are similiar, and comparable to the calculated contact time by Fiala and Japanese Hydrographic Office. The flattening index for $1.07 \leq r \leq 1.13$ rather deviates from the straight line, which might be affected by clouds.

Because there will occur a total solar eclipse on March 18, 1988 on Sumatra and Kalimantan, so the experience obtained during the 1983 solar eclipse is worthy and can be used for contact time determination and coronal structure observation using a better telescope.

ACKNOWLEDGMENT

We want to acknowledge that the obtained success of the total solar eclipse observation conducted in Indonesia and also the making of the report on the observation were brought into reality by a good cooperation between several Japanese and Indonesian scientific Institutes envolving on the operation of observation. Also we would like to express our sincere gratitude to certain figures from the Japanese and Indonesian Institutes as well who have given their important contributions for the success of aiming the targets of the observation.

Therefore we would like to express our sincere gratitude to:

1. Ir. J. Soegijo, Head of the Aerospace Research Center of the Indonesian National Institute of Aeronautics and Space (LAPAN) for his encouregements to the whole observing teams so the planned targets were successfully obtained.

2. Ir. Muchtisar, the Director of the Indonesian Institute of Oil and Gas "LEMIGAS", Cepu and his staff for their kind permittance to us to use LEMIGAS housing and facilities during the observation.

3. Prof. Dr. Eijiro Hiei and his Staff at Tokyo Astronomical Observatory, University of Tokyo, for their very worthy efforts and advices during important discussions on the preparations of the observation and for all his true dedications for the success of the observing operation.

4. Dr. Takao Saito and his Staff at Onagawa Magnetic Observatory, Faculty of Science, Tohoku University, Japan on his goodwill in giving permission to us to use their universal time as a refrence of our time used on total solar eclipse.

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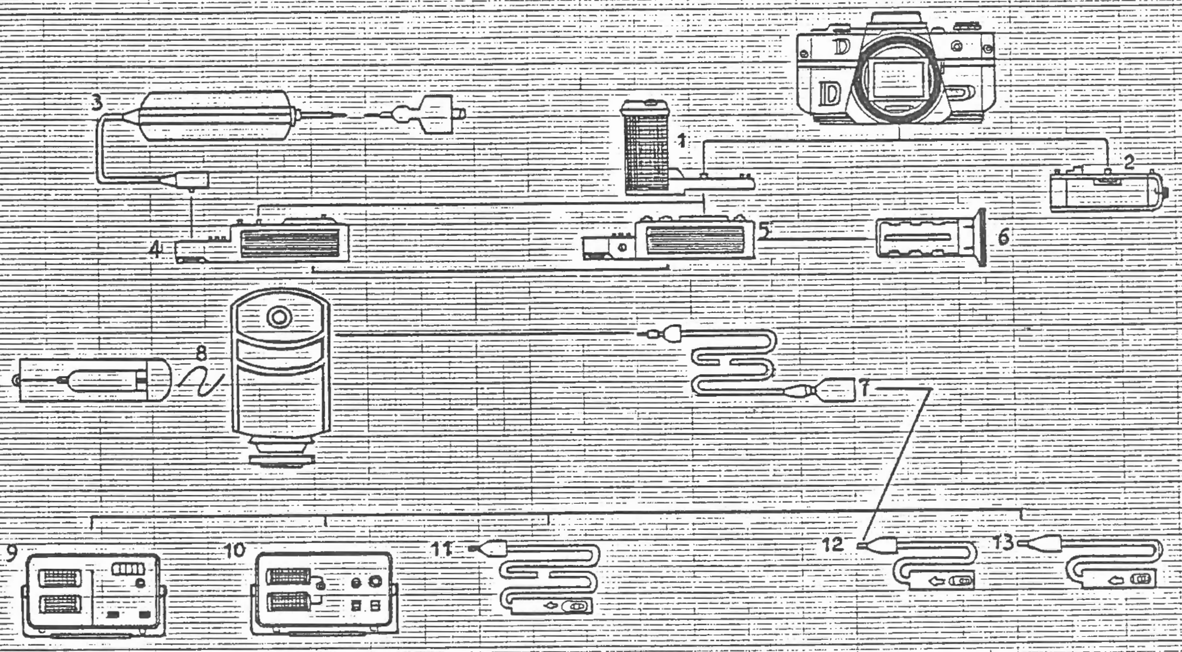
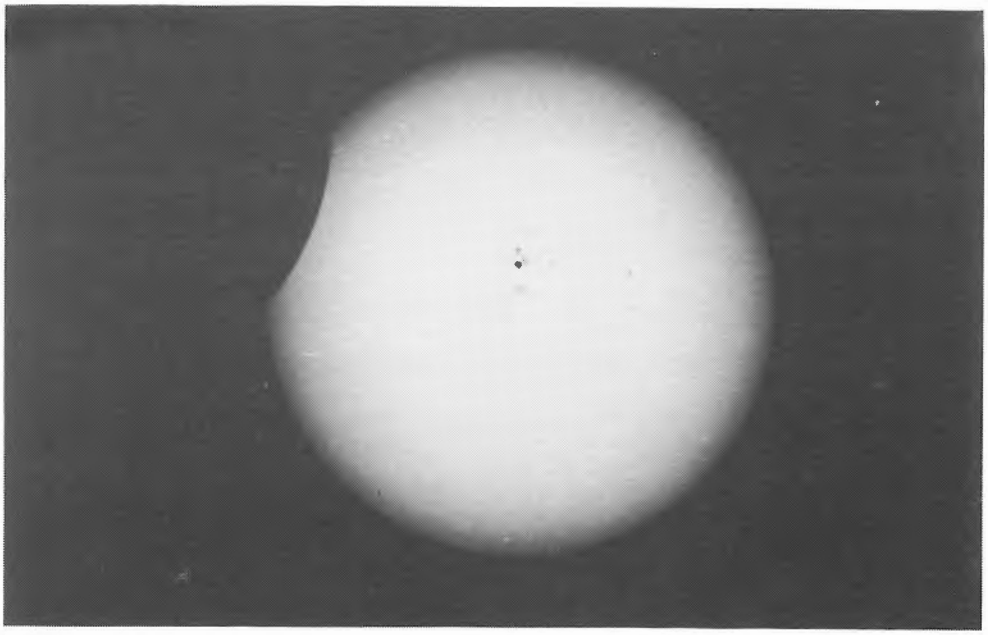


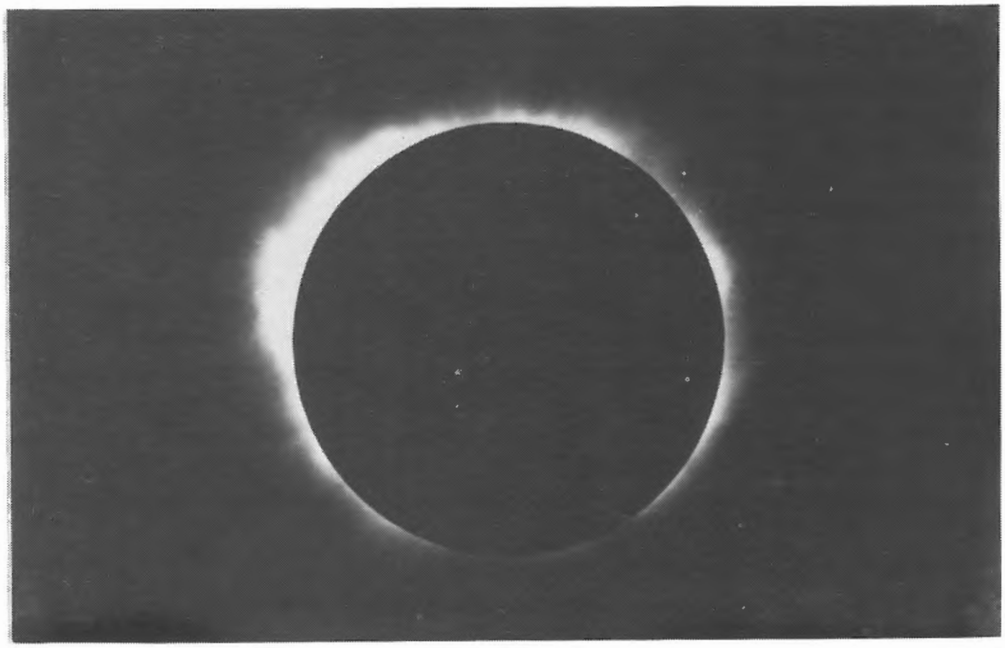
Fig 1 : Schematic of Cannon F-1 camera and it's accessories.

1. Motor Drive MA.
2. Power Winder A.
3. Ni-Cd Charger MA.
4. Ni-Cd Pack MA.
5. Battery Pack MA
6. Battery Magazine MA
7. Extension Cord E-1000
8. Wireless Controller LC-1
9. Time lapse programmer A unit
10. Time lapse Programmer B unit
11. Remote Switch 3
12. Remote Switch 60
13. Remote Switch 60 MF

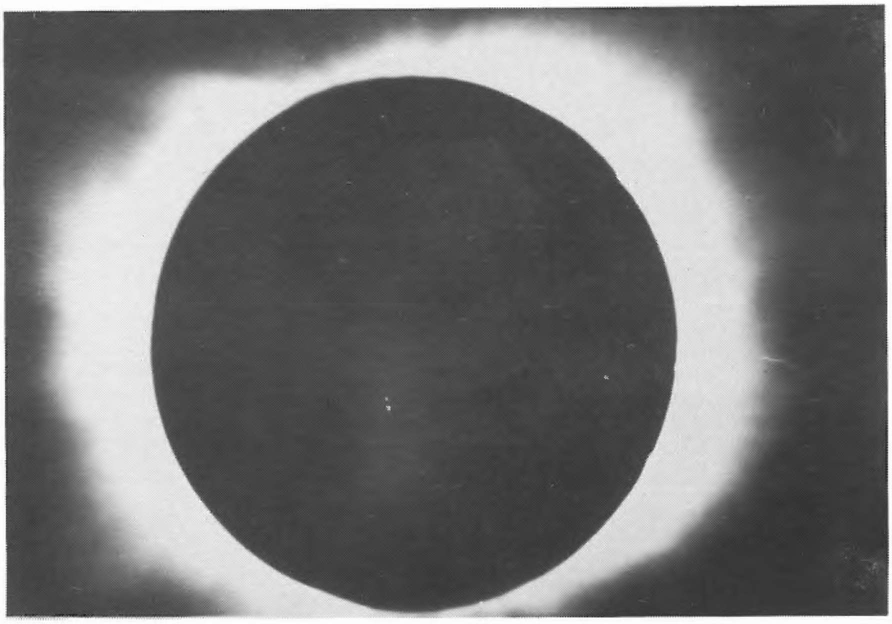
Observation of the eclipse by LAPAN's team at Cepu.



The sun at 03h 04m U.T. taken by using C-5 telescope and automatic speed camera.



The total solar eclipse at 04h 35m 30s U.T. taken by C-5 telescope with two seconds of exposure time.



The total solar eclipse at 04h 33m 57s U.T. taken by C-8 telescope with four seconds of exposure time.

BALLOON OBSERVATION OF THE 1983 SOLAR ECLIPSE IN INDONESIA

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ABSTRACT

A balloon observation of the total solar eclipse on 11 June 1983 was carried out as a cooperative work between Japanese and Indonesian teams. The observation was a photo-polarimetry of the F corona in both visual and near-infrared regions.

The balloon of 15,000-m^3 with a payload of 150-kg was launched at 7^h13^m on 11 June from Watukosek Balloon Base in East Java. Observation at an altitude of 30.5-km was successfully made during the totality ($11^h28{\sim}32^m$) at a position of ∿40-km east-south-east from Jogjakarta.

As a preliminary result, an excess in infrared brightness has been found near the position of 3.8$R_\odot$ west from the sun, which may be due to thermal emission from a high-temperature dust cloud located around the sun.

INTRODUCTION

The total solar eclipse on 11 June 1983 began at sunrise in south Indian Ocean, swept across mainly the Indonesian islands, and ended at sunset in south Pacific Ocean. Along the path, Java was the most favorable place for observation, since the totality occured there just before local noon and its duration reached more than 5 minutes on the central line of the eclipse.

This paper was presented at the COSPAR Meeting, Graz, 1984.

This paper is a report on a balloon observation of the eclipse which was carried out in Java under a cooperation between Japanese and Indonesian teams. The observation was a photo-polarimetry of the F corona in both visual and near-infrared regions using an imaging and a scanning photometers, respectively. We achieved to obtain all the data intended.

PURPOSE OF OBSERVATION

F corona is the sunlight scattered and diffracted by the interplanetary dust and, therefore, its observation provides information on the dust located near the sun. However, because of its faintness, the F corona can be observed only at the time of total solar eclipse.

Main purpose of our F corona observation at this eclipse was to find precise position of the boundary of dust free zone around the sun, where the interplanetary dust approaching to the sun begins to sublimate due to temperature increase.

Observation from a balloon altitude is necessary for infrared measurement in order to avoid strong absorption by the lower atmosphere. As seen in Fig. 1, it is also much advantageous for visual region measurement in reducing the background sky brightness which is caused by atmospheric scattered light coming from outside of the zone of totality.

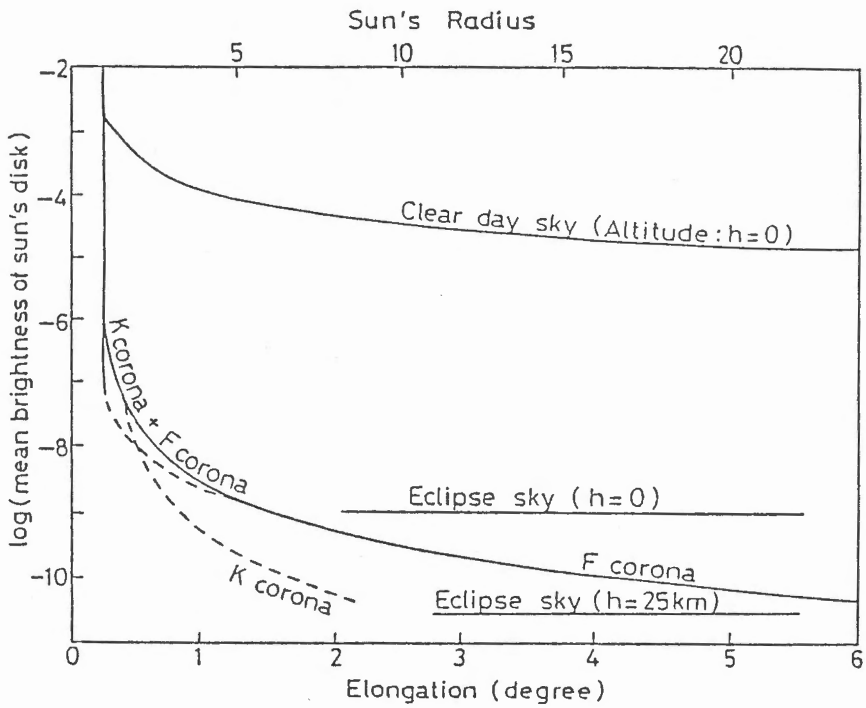

Fig. 1. Brightness of the corona and sky (from /1/). Center of the sun is at left end of abscissa.

PREPARATION PHASE

In 1980 the Japanese team began to study the feasibility of a balloon observation at the 1983 solar eclipse in Indonesia, and the Japan-Indonesia cooperative plan started in 1981 when Dr. R. Sunaryo, Director of Indonesian National Institute of Aeronautics and Space (LAPAN), visited Japan. Since then some of members of both teams visited each other country for detailed discussion and arrangements of the project.

The balloon and payload —— photometers, telemeter and recorder, attitude controller, remote controller etc. —— had been prepared in Japan. Performance test of these instruments was made by a balloon flight at Sanriku Balloon Center of the Institute of Space and Aeronautical Science (ISAS), Japan, in September 1982.

On the other hand in Indonesia, LAPAN started to construct a new balloon launching base at Watukosek in East Java and completed it early in 1983. The campus of the base, having three main buildings and a launching field, covers a hill area. Ground equipments —— receiving and transmitting system with 1 mϕ parabola and Yagi antennas, gas injection system, launcher etc. —— have been provided. Surface wind at the base is usually calm.

The final assembly of the payload and adjustment of the ground equipments were made after arrival of both teams at Watukosek Balloon Base around 20 May 1983.

Several rubber balloons were launched during this period in order to find the detailed wind condition in the stratosphere. In the tropics, stratospheric wind direction alternates between easterly and westerly with a period of 26 months (see /2/), and a prediction /3/ showed that the eclipse time of June 1983 would be just in its reversal period. However, from the results of our rubber balloons and meteorological rockets of LAPAN, we found that the wind direction of 25-km layer and upward is easterly, and is favorable for our eclipse observation.

On 5 June, we launched a balloon of 5,000-m^3 with a payload of 20-kg for a test of telemetry, remote control and ranging systems and for rehearsals of launching and recovery. After 3 hours flight at a level of 28-km, the payload was cut down from the balloon by remote control, and was recovered in the mountain area of $\sim$100-km west from Watukosek.

The final decision of the launching time of the eclipse day was made with considering data of stratospheric wind direction and speed obtained until 10 June.

INSTRUMENTS

For the infrared observation, horizontal scan (approximately along the ecliptic) between $\pm 2\overset{\circ}{.}5$ from the eclipsed sun was repeated by a 15-cm

Cassegrain reflector (F/4) with cooled PbS array detectors. The field of view of a single detector is 5.'7×5.'7. It measures the brightness in 4 wavelength bands of 1.25-μm, 1.65-μm, 2.25-μm and 2.8-μm, as well as the polarization at 2.25-μm, simultaneously.

An SIT (Silicon Intensifier Target) television camera with a 50-mm objective lens (F/2) was used for the visual region observation. In order to eliminate the effect of the bright inner corona, it has an occulting disk, of which radius corresponds to $3.5R_\odot$ ($R_\odot$ = sun's radius) at the direct focus. The camera measures the brightness and polarization distributions in a sky area of 5°×5° centered at the sun with exchanging 4 interference filters of 5325-Å, 5965-Å, 7200-Å and 8015-Å and a rotating polarizer.

The SIT camera was also used for monitoring the sun during the partial phase of the eclipse through a small iris and a density filter.

Both infrared and visual photometers were set on a same mounting in a gondola, and its elevation angle could be changed by remote control while watching a monitor-display at Watukosek Base. The azimuth angle of the gondola was controlled by the attitude control system developed at ISAS /4/. The system consists of a reaction wheel in the gondola, a twisting motor at the middle of the rope and a geomagnetic sensor. 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 measured by both photometers were recorded in a video tape recorder on board, and a part of them was transmitted to the ground through the telemeter.

OBSERVATION

The eclipse balloon of 15,000-m^3 was launched at 7^h13^m local time on 11 June with a payload of 150-kg, of which construction is shown in Fig. 2. The sky was clear with partial thin cloud and the surface wind was easterly 0.5-m/sec.

The balloon attended to the level altitude of 30.8-km at 8^h37^m, then drifted to west-south-west direction with a speed of 80-km/h. In order to bring it close to the central line of the eclipse, we released ballast three times after 10^h, and could change the drift direction slightly to westward by raising its flight level to 32-km. Trajectries of the balloon are shown in Figs. 3 and 4. The altitude of the balloon began to decrease from around 11^h with a rate of -70-m/min. It is due to weakening of the solar radiation by progressing the partial eclipse.

The balloon encountered shadow of the moon at 11^h28^m at a position of ∿40-km east-south-east from Jogjakarta. Duration of totality at the balloon was 3^m50^s. Immediately after the 2nd contact, the observation

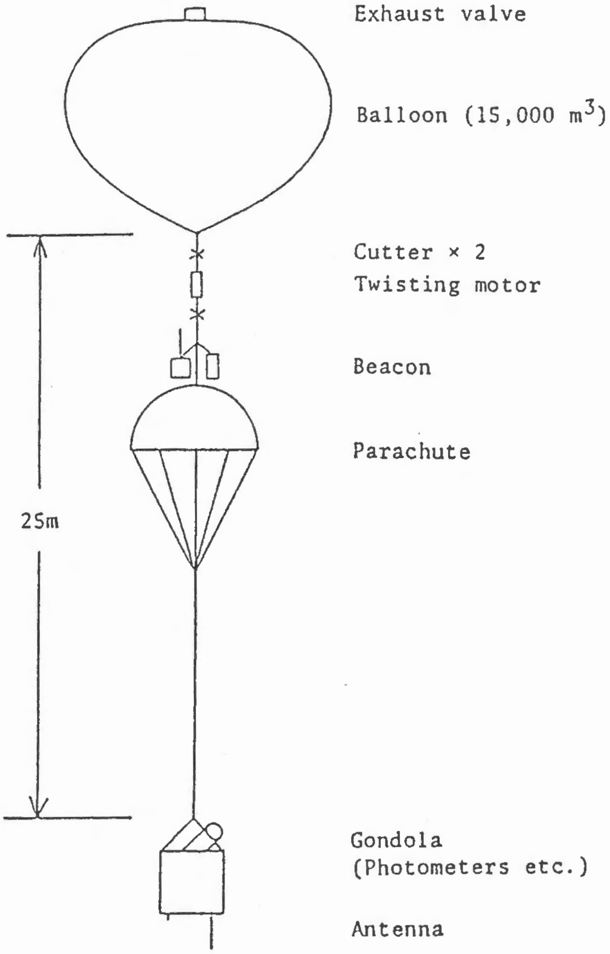

Fig. 2. Construction of the balloon.

was started by switching on through remote control. The instruments worked properly throughout the totality under attitude control within ±8 arc seconds.

After the observation, the payload was separated from the balloon and landed safely by a parachute. We recovered it on the next day.

PRELIMINARY RESULT

Analyses of both visual and infrared data are in progress in Japan, mainly at Tokyo Astronomical Observatory and Kyoto University, respectively, but we do not obtain yet the final results. However, a pre-

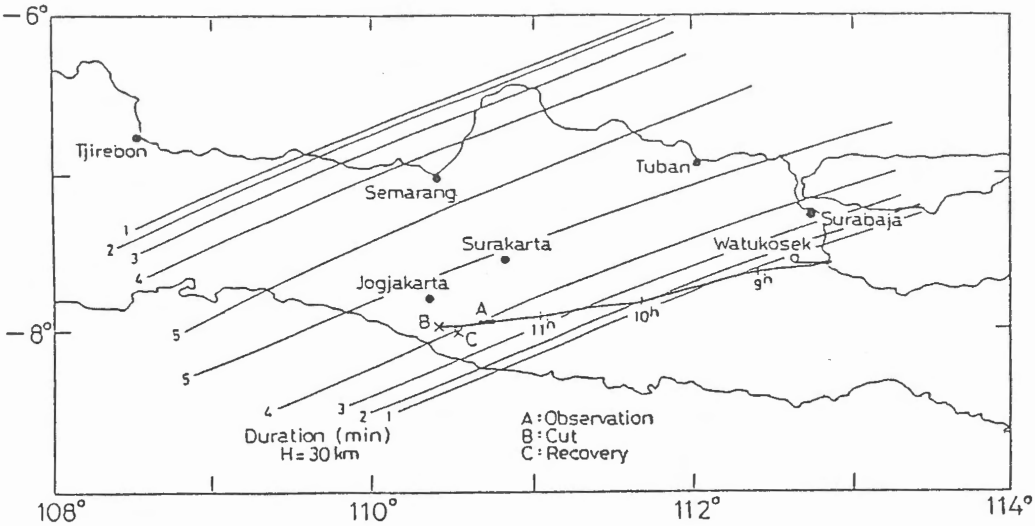

Fig. 3. Trajectry of the balloon, 11 June 1983.
Durations of the totality in the eclipse zone are indicated.

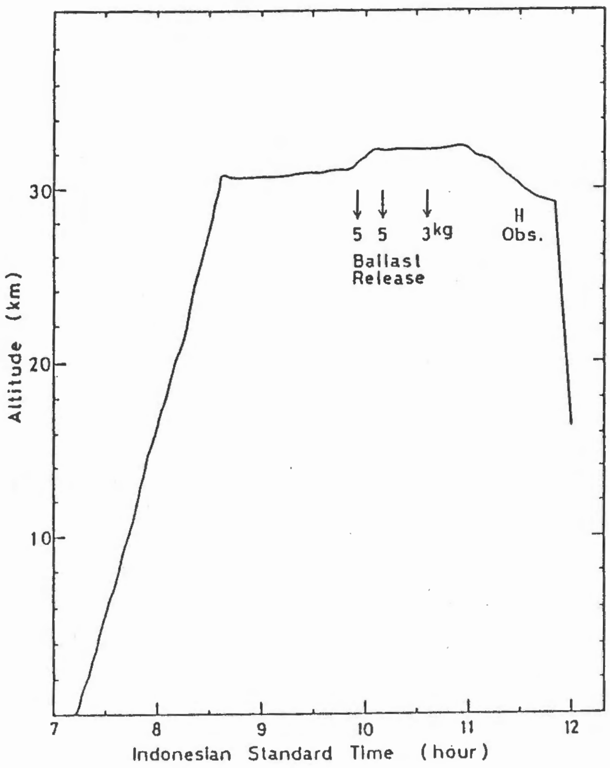

Fig. 4. Altitude trajectry of the balloon, 11 June 1983.

liminary result shows that there exists an excess of infrared brightness around $3.8R_\odot$ west from the sun as seen in Fig. 5, as an example. It may be due to thermal radiation from a hot dust cloud located near the boundary of the dust free zone, which is similar to the excess emission at 2.2-μm observed by Peterson /5/ and MacQueen /6/ previously.

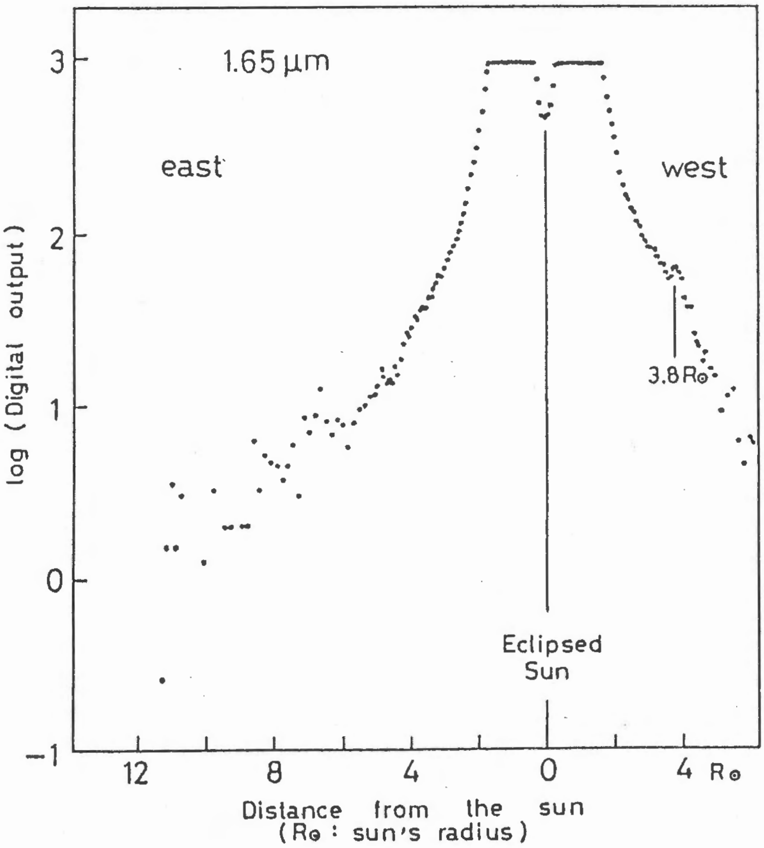

Fig. 5. Infrared scan profile at 1.65-μm.

We acknowledge the governments of Japan and Indonesia for their great support to our cooperative project.

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APPENDIX

(1) Stratospheric Wind in Indonesia

Since Watukosek Balloon Base is located in the east side (near the line of southern limit) of the eclipse zone, which lied across the island of Java from south-west to north-east, we had to have easterly stratospheric wind in order to bring the balloon into the zone of totality.

However, as shown in Fig. 6 (and see /2/), the tropical stratospheric wind direction alternates between easterly and westerly with an average period of 26 months. The reversal from one to the other direction occures first at a level of more than 30-km, and propagates downward with a rate of about 1-km/month. This phenomenan is called the "quasi-biennial oscillation (QBO)".

Analyzing the previous QBO data together with recent data of Singapore (see Fig. 7) and LAPAN's data in Indonesia, Yamanaka /3/ predicted the wind condition at the eclipse time that :

1) June 1983 would be in a reversal period of the wind direction from westerly to easterly at 25-km level,
2) The wind directions below the 25-km level would be westerly, but near 30-km would be easterly, and at 35-km and upward might be westerly again.

At Watukosek, we had prepared two kinds of balloons, of which volumes are 5,000-m^3 and 15,000-m^3. The former balloon can reach to an altitude of about 24-km and the latter to 30-km with a payload of 150-kg. Between them, we finally selected the balloon of 15,000-m^3 for the eclipse observation in order to reach to the easterly wind layer according to Yamanaka's prediction and other wind data including rubber balloon flights.

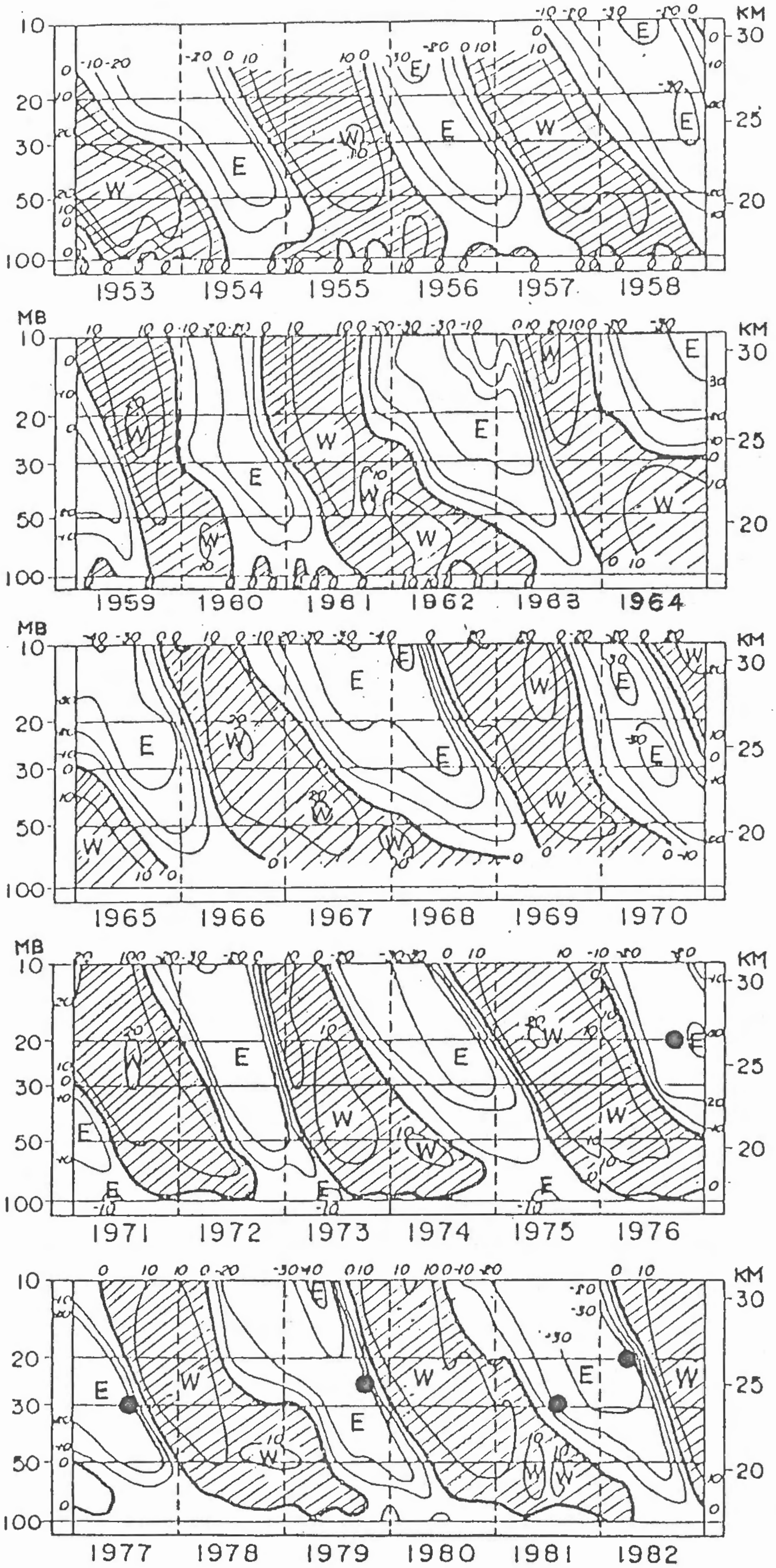

Fig. 6. Time-height section of the monthly mean of easterly (E) and westerly (W) wind speed in the tropical lower stratosphere (from T. Maruyama : Proc. MAP Symp., ISAS, p. 129 (1983)). Black circles plotted after 1976 indicate LAPAN's previous balloon flights.

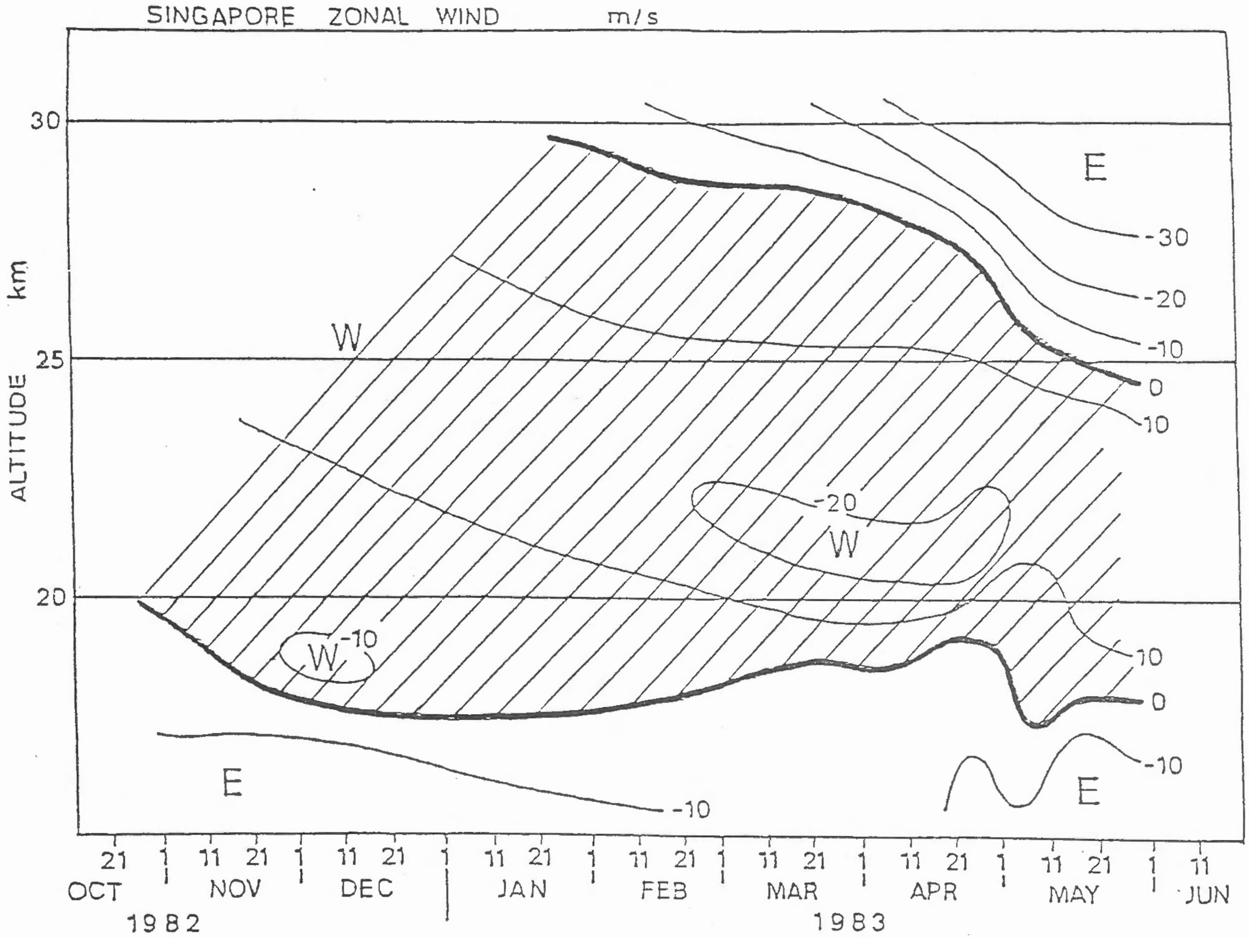

Fig. 7. Time-height section of the QBO depicted from recent Singapore data /3/.

(2) Data of the Balloons

Data of two balloons; test flight and eclipse observation, launched from Watukosek for our eclipse project are indicated in Table 1. The trajectries of the eclipse balloon on 11 June are shown in the text (Figs. 3 and 4).

Besides these two balloons, 10 small rubber balloons were launched during three weeks prior to the eclipse day to find the detailed wind condition in the stratosphere. As an example of these rubber balloons, trajectories of a flight on 10 June are shown in Figs. 8 and 9. Data of the wind measured by the rubber balloons generally accord with Yamanaka's prediction.

Table 1

	Test Flight	Eclipse Obs
Launch		
Date	5 June 1983	11 June 1983
Time (LT)	$8^h\ 23^m$	$7^h\ 13^m$
Balloon		
Volume (m^3)	5000	15000
Length (m)	33.5	47.3
Diameter (m)	22.6	33.4
Rope length (m)	23	25
Weight (kg)		
Balloon	41.5	75.2
Payload	19.1	120.4
Parachute	6.6	11.6
Ballast	25.0	30.0
Total	92.2	237.2
Free lift (kg)	11.1	26.0
Ascending velocity (m/min)	339	340
Level flight (km)	28.0	30.8
Expected (km)	29.7	30.7

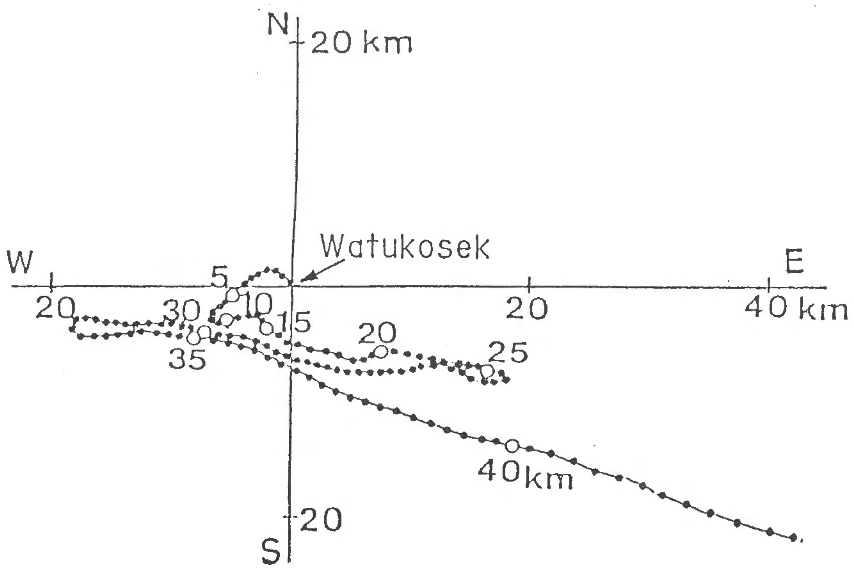

Fig. 8. Trajectory of the rubber balloon flight on 10 June 1983.

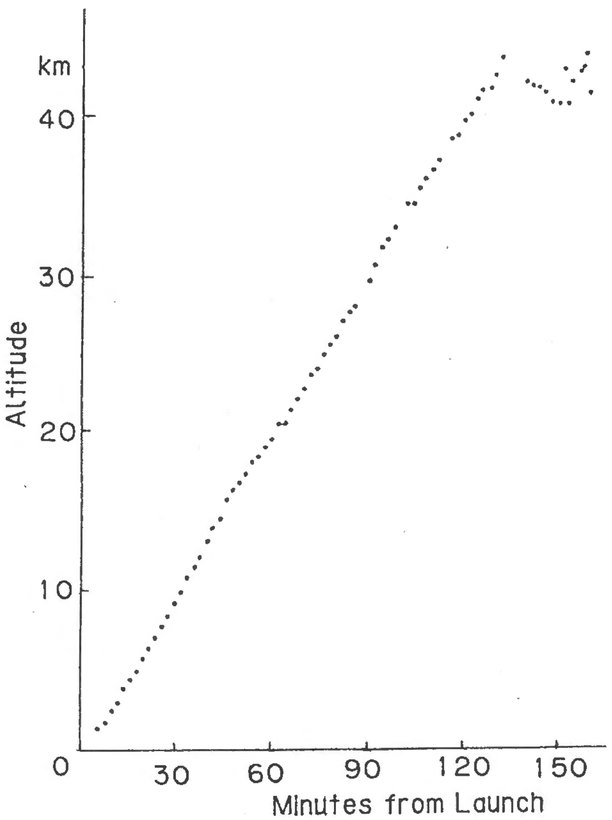

Fig. 9. Altitude trajectory of the rubber balloon flight on 10 June 1983.

WATUKOSEK STRATOSPHERIC BALLOON LAUNCHING STATION

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INTRODUCTION

Indonesian National Institute of Aeronautics and Space (LAPAN) constructed a new balloon launching station at Watukosek, Pasuruan, East Java, and it was formally inaugurated by Dr. R. Sunaryo, Chairman of LAPAN, on 4 May 1983.

Watukosek Stratospheric Balloon Launching Station is located at geographic coordinates of 112°41'E and 07°34'S only 30km south of Surabaya city (about 30 minutes by car). The station lies on a hill covering an area of 15 ha. The land wind is continuingly calm condition. The trajectories of balloons launched from this station can be arranged to be easterly or westerly or boomerang-like depending on the stratospheric wind condition.

The first project of balloon observation conducted at this station was the 1983 Solar Eclipse Observation Research in June 1983, which was a cooperative work between LAPAN and Japan balloon teams.

FACILITIES

Watukosek Stratospheric Balloon Launching Station is provided (as of January 1985) with the following construction and equipment facilities.

1. Construction Facilities
   a. Commander's Building, covering 150 m^2, consists of :
      (I) Commander's Room
      (II) Preparation Room
      (III) Assembling Room
   b. Tracking Building, covering 200 m^2, consists of :
      (I) Tracking Room
      (II) Telecommand Room
      (III) Meteo Room

(IV) Communication Room
(V) Meeting Room
(VI) Administration Room

c. Guest House, covering 140 m^2
d. Balloon Fabrication Building, covering 560 m^2
e. Electricity
(I) Two Generators, each consisting of 20 KVA
(II) PLN (State Electric Company) 53 KVA

2. Equipment Facilities

a. Tracking System
2 pieces of Rawinsonde RD 65 cs*(Japan)
Frequency : 1680 MHz
Airborne : 300 m Watt
Automatic Tracking
* will be increased to become Ranging System in 1985

b. Telemetry
Astrodata (West Germany)
Frequency : 150 - 260 MHz
18 Channels
Mannual Tracking

c. Telecommand
Balte 4 CSEE (France)
PCM/PSK/FM : 10 addresses
10 orders / Count orders
Frequency : 444 MHz

d. Homer / Beacon (France)
Frequency : 122.0, 122.5, 123.0 MHZ
Power : 300 m Watt

e. Launcher : Capacity up to 500 kg

f. Gas(H_2) Injection System

g. Communication
F.T. 101 Yatsu (Japan)
Frequency : 7.616 MHz
Power : 100 Watt

h. Recovery
- By car
- By helicopter

i. Equipments for balloon manufactory

Some of above facilities were not provided yet or not used at the time of the solar eclipse in June 1983.

3. Personnel
Lapan's team for balloon launching consists of 30 people.

THE 1983 SOLAR ECLIPSE OBSERVATION

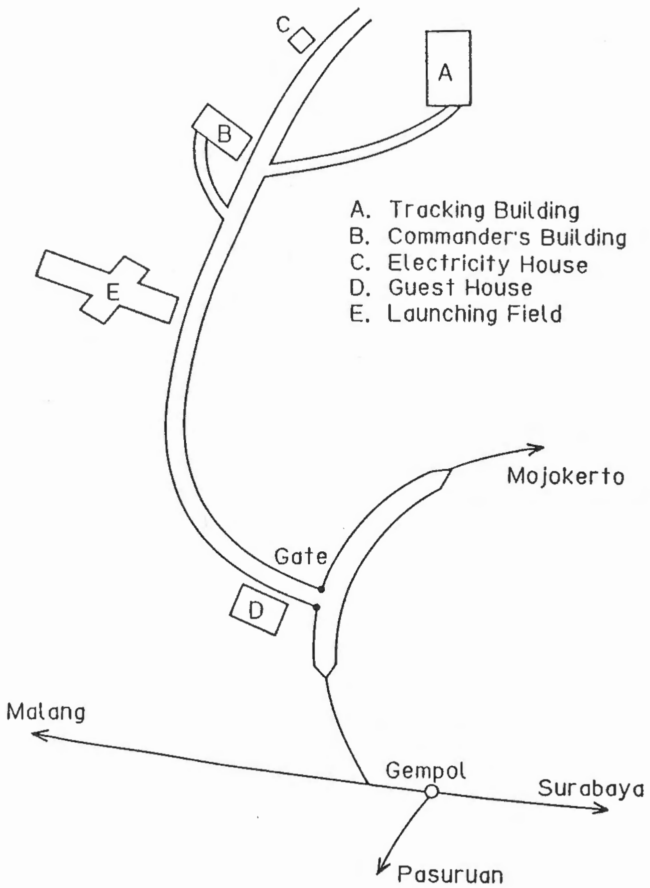
The first balloon launching at this station was made on 5 June, 1983. The balloon of 5,000m^3 was launched for a rehearsal of the eclipse observation. It flew 3 hours at a level of 28km, and the payload landed by a parachute was recovered by LAPAN-Japan recovery team in the mountain area of about 100km west of Watukosek.

The balloon of 15,000m^3 for eclipse observation was launched at 7^h13^m on 11 June 1983. The balloon reached to 30.8km altitude and drifted to west-south-west direction. The observation was successfully carried out at a position of about 40km east-south-east from Jogjakarta.

Immediately after launching the balloon, LAPAN-Japan recovery team started by car from Watukosek to the west following the balloon. We recovered the payload perfectly on the next day.

By this balloon observation, we could detect the solar dust ring around the sun.

OUTLINE OF WATUKOSEK STRATOSPHERIC BALLOON LAUNCHING STATION (June 1983)



Balloon Launching at Watukosek
11 June 1983

ATTITUDE CONTROL SYSTEMS FOR A BALLOON ECLIPSE EXPERIMENT IN INDONESIA

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ABSTRACT

For a preceise attitude control for a balloon borne telescope, a system was developed by using a reaction wheel. The system has also an active bearing to avoid the torque due to the suspension rope between the balloon and gondola. The motion of the gondola during this control is fully analyzed to find the most appropriate parameters to the reaction wheel and the achieve bearing.

This attitude control system was applied to the balloon borne tlelescope to observe the dust ring around the sun at the time of eclipse occured in Indonesia on June 11, 1983, and achieved the pointing accuracy of several arc second.

1. INTRODUCTION

The attitude control system of "Twisting by Suspension Rope Method" (Ref.1) has been widely used in Japan for the observation of celestial bodies with balloon borne telescopes. The system is simple and has advantage of low cost, but the pointing accuracy is limited to about 1 arc degree or so.

We planned observing the dust ring around the sun by a balloon borne telescope taking advantage of the total eclipse which occured over Jawa Island on June 11, 1983. In this experiment, the demanded pointing accuracy was at least about 1 arc min, and therefore it required development of a new system of attitude control with higher accuracy than that of the twisting suspension rope system. Thus we decided to use the pointing system of reaction wheel for this experiment, which has been under development by the groups at Kyoto University (Ref.2) and at ISAS. In this system, a reaction wheel is used as a torquing device, and a small twisting motor is put in the suspension rope to decouple the rotational motions of the balloon to the gondola. This twisting motor is also used to unload the reaction wheel.

First, we studied this system in an analytic way to examine the detailed motion of the payload which depends on the various parameters for driving the reaction wheel and the twisting motor. After finding the optimum parameters for this system, the motion of the telescope was simulated by an electronic computer to examine if the results obtained with the analytic way are reproduced by this simulation.

Next, we provided a test gondola with this pointing system, and confirmed that the test results agree quite well with those predicted by the analytical studies. We found that the details of the pointing system can be completely analyzed in an analytic way.

The experiment was performed at the time of the total eclipse using this control system, and we succeeded in pointing the telescope at the sun with an accuracy of several arc seconds. We are also investigating development of simpler and light weight pointing devices of this type which will be useful for observations requiring pointing of a telescope is an accuracy of the orders of arc seconds.

2. POINTING SYSTEM

The pointing system we adopted is shown in Fig.1. We also put a small twisting motor in the suspension rope to avoid the effect of the torque due to this rope. Besides acting as an active bearing, this twisting motor also works to unload the reaction wheel. In order to analyze this system, we use the following simboles:

- the error angle of the telescope: θ
- the rotational angle of the wheel: ϕ
- the rotational angle of twisting motor: θ_1
- the ratio of the moment of inertia of the wheel to that of the payload: J
- the free angular frequency of the payload by the torque of suspension rope: ω_0

Then the equation of the rotational motion of the payload is given by

$$\ddot{\theta} = -J\ddot{\phi} - \omega_0^2 (\theta - \theta_0) \quad . \qquad (1)$$

For the applied current to drive the motor of the reaction wheel, we put the torque of the motor to be

$$J\ddot{\phi} = a\dot{\theta} + b\theta \quad . \qquad (2)$$

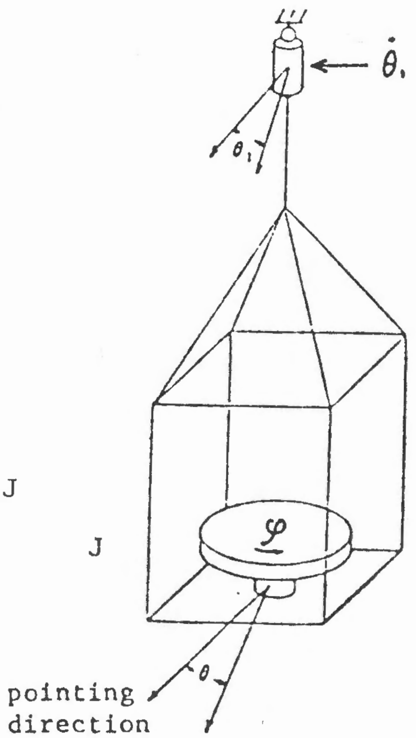

Fig.1 System of Attitude Control

in order the error angle, θ, of the payload converges to zero. We drive the twisting motor to minimize the torque of the suspension rope to the payload, and apply the voltage to the motor in a way,

$\dot{\theta} = -Ax$ (Torque of Suspension Rope),

where the torque of suspension rope is given by $-\omega_0{}^2(\theta - \theta_1)$ by definition.
Using eqs.(1) and (2), the torque is also represented by

$$-\omega_0{}^2(\theta - \theta_1) = \ddot{\theta} + J\ddot{\phi} = \ddot{\theta} + Ja\dot{\theta} + Jb\theta \quad , \qquad (3)$$

then, we have

$$\dot{\theta}_1 = -A\ (\ddot{\theta} + Ja\dot{\theta} + Jb\theta) \quad . \qquad (4)$$

We also put the term $B\dot{\phi}$ in this equation to unload the speeding up of reaction wheel using the torque of the suspension rope, and finally we apply the voltage to the twisting motors as

$$\dot{\theta} = -A\ (\ddot{\theta} + Ja\dot{\theta} + Jb\theta) - B\dot{\phi} \quad . \qquad (5)$$

Substituting $\dot{\theta}_1$ of eq.(5) into eq.(2), and eliminating $\dot{\theta}_1$, we find the stability of the motion of the payload is assured even if we neglect the terms of $\dot{\theta}$ and $\ddot{\theta}$ in eq.(5). Then instead of eq.(5), we have,

$$\dot{\theta}_1 = -C\theta - B\dot{\phi} \quad , \qquad (6)$$

where we put $AJb\,\theta = C\theta$. The equation of motion of the payload is now written by:

$$\ddddot{\theta} + Ja\dddot{\theta} + (Jb + \omega_0{}^2)\ddot{\theta} + \omega_0{}^2(Ba + C)\dot{\theta} + \omega_0{}^2Bb\theta = 0 \quad . \qquad (7)$$

3. SOLUTION OF THE EQUATION OF MOTION OF THE PAYLOAD

Since the equation of motion (7), is a 4th order differential equation, it is preferable to have some approximations to solve the equation.

First, we note that the value of ω_0, frequency of the free rotational oscillation of the payload, has generally a small numerical value. The period of the osciallation is generally about 2 - 3 min. Then we have

$$\omega_0{}^2 = (\ 2\pi/\ T\ )^2 \cong 10^{-3} \quad .$$

Having an approximation of $\omega_0^2 << 1$, we can separate eq.(7) into two differential equations,

$$\ddot{\theta} + Ja\dot{\theta} + b\theta = 0 \quad , \qquad (8)$$

$$\ddot{\theta} + \frac{\omega_0{}^2C}{Jb}\dot{\theta} + \frac{\omega_0{}^2B}{J}\theta = 0 \quad . \qquad (9)$$

If we put the characteristic roots of eqs.(8) and (9) as α,β and γ,δ respectively, we have the general solution of eq.(7) as

$$\theta = H_0e^{\alpha t} + H_1e^{\beta t} + H_3e^{\gamma t} + H_4e^{\delta t} \quad . \qquad (10)$$

The orders of magnitude of α, β, γ and δ are given by the eqs. (8) and (9) as

$$\alpha,\beta = 0(Ja) \quad , \qquad \gamma,\delta = 0(\omega_0{}^2\frac{C}{Jb}) \quad .$$

Thus we see the motion of the payload damps rapidly by the solution of α and β at first, and later, damps smoothly by the solution of γ and δ.

3-1. PROPORTIONAL REGION

If we neglect the possible nonlinear effects due to the motion of the motors, the motion of the payload is finally determined by the terms of

$$H_2 e^{\gamma t} + H_3 e^{\delta t}$$

given in eq.(10). The damping time, τ, is given by eq.(9), and is

$$\frac{1}{\tau} = \frac{\omega_0^2 C}{2Jb} .$$

The residual error angle of the payload is now given by, assuming the initial condition of

$$\theta r = \frac{\omega_0^2 aC}{Jb} e^{-\frac{t}{2}} \theta_0 = \frac{2}{\tau} \frac{a}{b} e^{-\frac{t}{\tau}} \theta_0 . \quad (11)$$

As seen in the above formula, the damping time is essentially determined by the ratio of

$$C/Jb. \quad (12)$$

If we have larger values of τ, we can expect smaller values for the residual deviation angle, but it takes longer time for the damping of the motion as seen from eq.(11).

For the effect of the disturbances to the payload such as due to the rotational motion of the balloon, we examine the case of the disturbances for

uniform rotation of the balloon: F_1 (rad/sec)
oscillatory motion of the balloon: $F_2 e^{i\omega t}$ (rad/sec).

In the case of a combination of above disturbances, we have the following value for the residual deviation angle from eqs.(2) and (5)

$$\theta r = \frac{\omega_0^2}{2Jb} (F_1 + F_2) . \quad (13)$$

Thus, we have to fix the lower limit of Jb to assure a certain value of this residual deviation angle.

3-2. NON PROPORTIONAL REGION

When we start the control, it is generally of non proportional type, since the motor of reaction wheel should be limited within a range of maximum torquing and the twisting motor has a maximum rotational speed. These conditions can be described from the formula (2) and (6) as

$$|\ddot{\phi}| = |a\dot{\theta} + b\theta| \leq \text{(Maximum torque of the motor)/(moment of intertia of the wheel)} , \quad (14)$$

and

$$|\dot{\theta}| = |C\theta + B\dot{\phi}| \leq \text{maximum rotational speed.} \quad (15)$$

When $|\ddot{\phi}|$ is beyond a certain value, the control is on-off type. Analyzing the case of on-off control by using eqs.(2) and (5), we find the motion of the payload is determined by the values of a/b, and B/C, corresponding to the solution of (α,β) and (γ,δ) respectively.

3-3. OPTIMUM PARAMETERS FOR THE CONTROL

Summarizing the results of analysis described in sections 3-1 and 3-2, we have the following constrains for the various parameters of the optimum control. Here we assume pointing accuracy of error angle, θ, should be less than 10^{-4} radian, about 20 arc sec, after about 10 min of control.

i) For the on-off control region, we have

$$a/b = 1 \quad , \qquad B/C \leq 10^{-3} \quad .$$

from the arguments in section 3-2.

ii) To reduce the effects of the disturbances, we have a constrain from eq.(12) assuming $F_1 = F_2 = 0.01$ rad/sec,

$$Jb > 1 \quad .$$

iii) For the proportional control region, we have constrains

$$C/Jb \leq 0.1 \text{ or } \geq 6.0 \quad ,$$

each condition correspond $\tau \lesssim 3 \cdot 10^2$ sec and $\tau \gtrsim 10^4$ sec in eq.(11).

For the actual design of this control system, we first assume the ratio of the moments of intertia, J, to be 1/30. Next we assume that the value for a is about 100. According to the constrains given above, we can fix the following values for each parameter.

$$b = 100 \quad ,$$
$$C = 100 \quad ,$$
$$B = 0.05 \quad .$$

The simulation of the motion of the payload with an electronic computer is performed with these parameters, and the results are shown in Fig.2. Simulations with combination of other values of parameters are also performed, and we found that the above parameters derived in an analytical way give the most satisfactory results for the control of the payload.

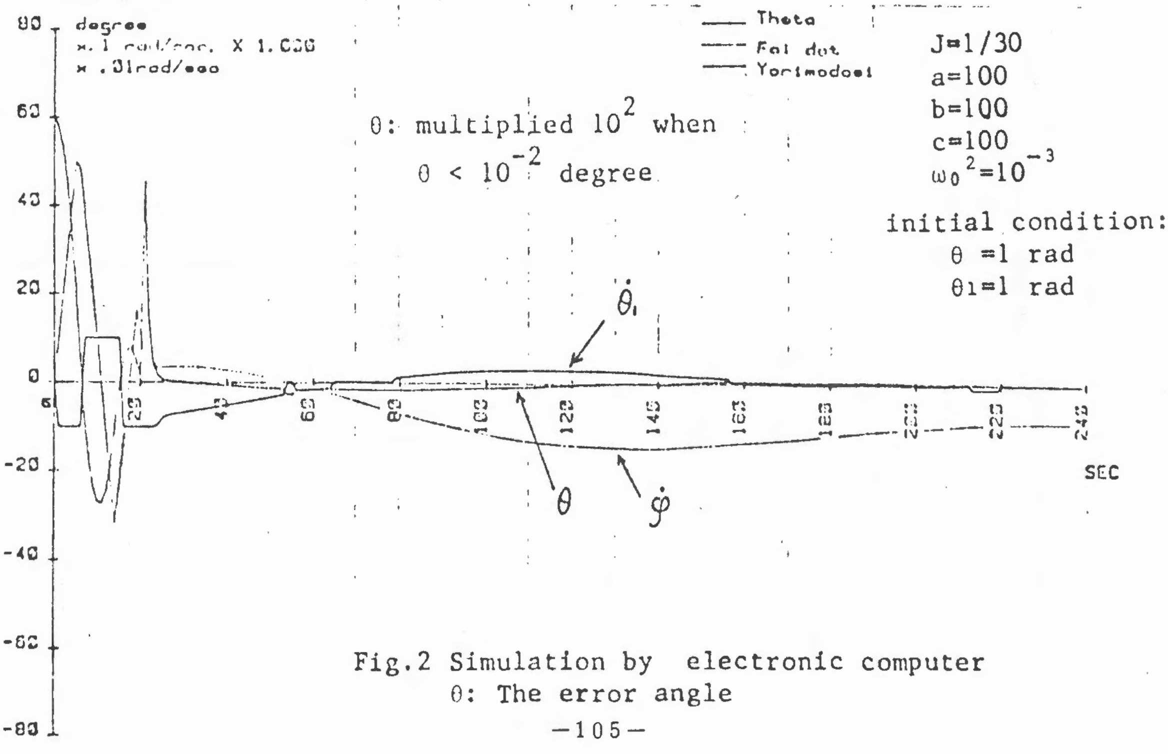

Fig.2 Simulation by electronic computer
θ: The error angle

4. ACTUAL CONTROL SYSTEMS AND GROUND TEST

In order to see the performance of this system, the ground test was performed. The total weight of the payload is 120 kg, and its moment of intertia is about 150,000 kg cm^2. We use a reaction wheel of 56 cm dia. made from aluminium. The weight of the wheel is 7.8 kg and its moment of inertia is 4,600 kg cm^2. The motor is a direct driving type (T-2967-A, Inland. Co. Ltd. U.S.A.), and its maximum torque is 6 kg cm. The maximum speed of twisting motor is 2 r.p.m.

The period of free rotational oscillation, T, is about 2 min, and thus

$$\omega_0{}^2 = \left(\frac{2\pi}{T}\right)^2 = 2.7 \times 10^{-3}$$

We used a geomagnetic sensor as an attitude sensor for this ground test. The performance of the control is shown in Fig.3, the pointing accuracy of about 1 arc min was achieved. Better accuracy was expected, since there existed a considerable disturbance of the magnetic field in the laboratory where the test experiment was performed.

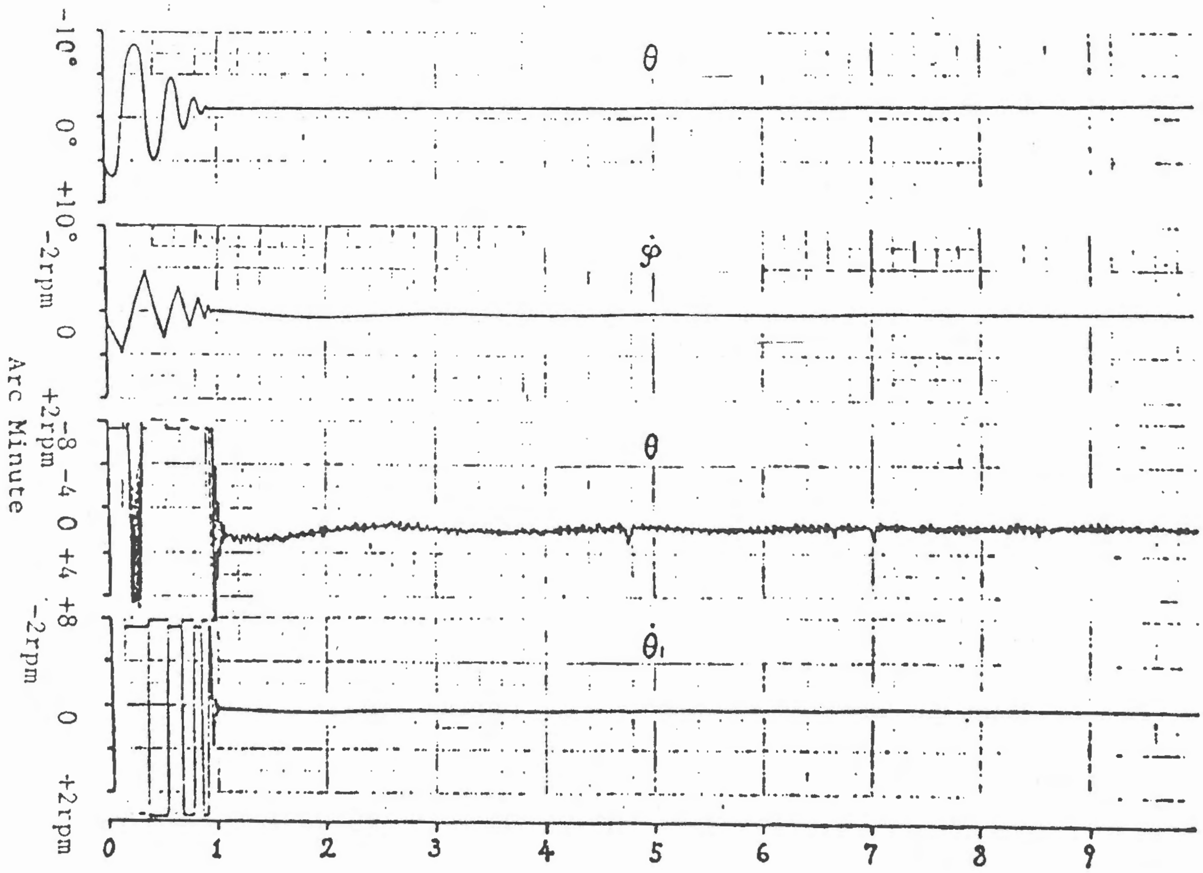

Fig.3 Data of the laboratory experiment

5. FLIGHT PERFORMANCE

The observation of the dust ring at the balloon altitude at the time of total exlipse was performed on June 11, 1983. The instrument to observe the dust ring has an infrared telescope to observe infrared in radiation in J, H, K and L bands, and SIT camera (silicon intensifier target) with filters of 5325, 5965, 7200, and 8015 Å with polarizer. All the observational data were recorded on a board tape recorder. The data acquired by infrared telescope and parts of TV camera data were also to be transmitted to the ground.

The attitude sensor for the control was a sun sensor, but geomagnetic sensor was used during the eclipse. The geomagnetic sensor was mounted on a table, which rotates with the same speed as the movement of the sun. Also, the pointing was to be monitored by SIT camera on board the balloon, and position of the sun was displayed on the TV monitor on the ground.

The balloon was launched at 7:13 am. of Indonesian Standard Time on June 11 from Watukosek balloon center of Lapan, Indonesia. It reached an altitude of 30.8 km at 8:37 am. The balloon encountered the shadow of the moon at 11:28 am. at a point approximately 40 km ESE of Jogjakarta. Duration of totality was 3 m 50 sec.

Because the gas inside the balloon started cooling down in the shadow of the moon during the eclipse, the balloon started descending with a speed of about 25 m/min. Despite this large disturbance due to the balloon motion, the pointing accuracy was kept within several arc second during the observation.

Fig.4 shows the pointing accuracy during the observation. The distribution of the error angle is also shown in Fig.5. We see one sigma deviation of the pointing is about 8 arc seconds. We also mention the pointing accuracy during the level flight before the eclipse was about 5 arc seconds, and the results were quite satisfactory.

Since most of the observations for celestial bodies in balloon borne astrophysics experiment demand accurate pointing systems, further improvements of this system seem useful for those observations. Our analytical investigation gives satisfactory results for the performance of the control system, and the analytical investigation of new light weight system with reaction wheel is now under progress.

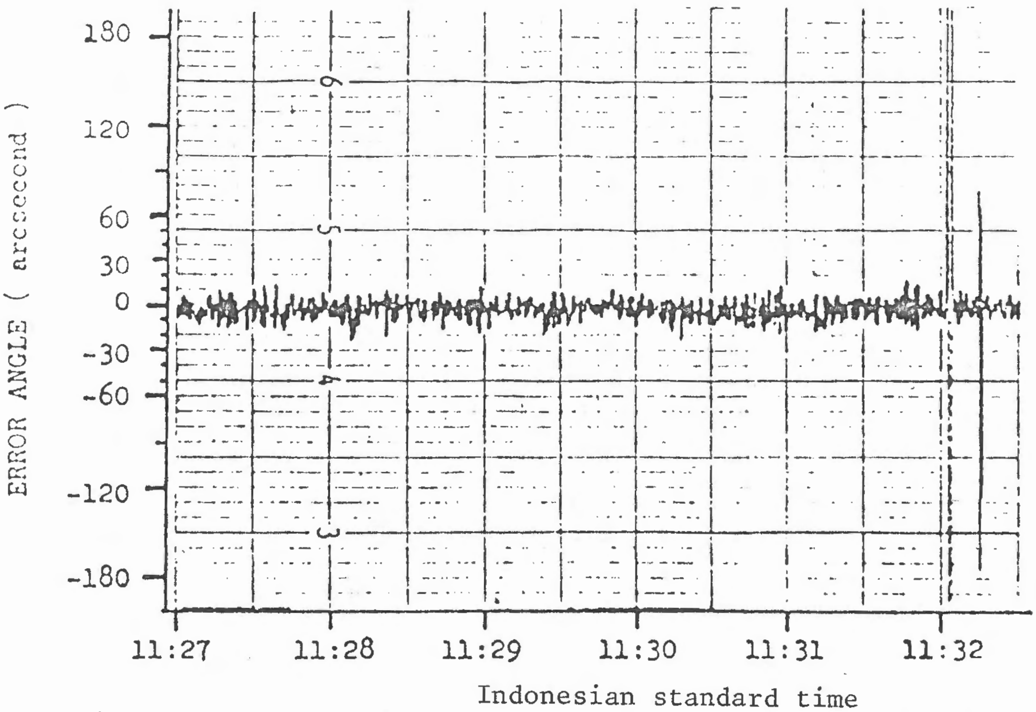

Fig.4 Pointing during the observation at the time of eclipse June 11, 1983

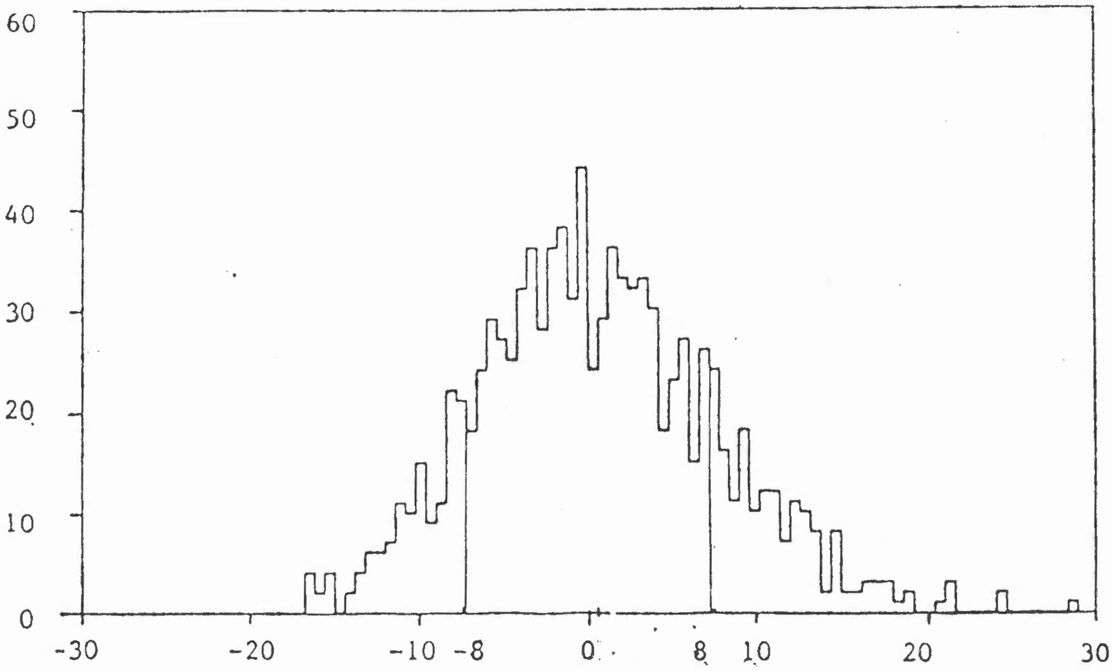

Fig.5 Distribution of error angle during the observation

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Data Acquisition and Recording System for two Dimensional Images of Solar Corona during a Balloon-Borne Observations of the Total Solar Eclipse on June 11, 1983.

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Abstract

On June 11, 1983, an observation of the outer solar corona at Jawa island in Indonesia has been carried out at 30 km altitude using a B15 balloon and showed that there are ring structures with high dust contents surrounding the sun. There were many difficulties for the observation, because light scattered by dust grains is not only very faint, but also sky background radiation varies much enen in a few seconds during total solar eclipse. To overcome these difficulties, we introduced a SIT (Silicon Intensifier Target) which is two-dimensional high sensitive detector. All data were recorded on video tape in analog way on board at 30 km altitude, and small fraction of data were sent to ground-based recorder. Both data were reduced later and it is found that noise level was so low that we could find ring structure surrounding the sun.

Key words: Two dimensional data storage, SIT camera, Video recorder.

1. Introduction

It is well-kown that there are dust grains in interplanetary space which spiral in toward the sun by the Poynting-Robertson effect and which evaporate at certain distances from the sun depending on grain materials.

Dust grains were expected to evaporate at arround the distance of four solar radius (we denote a solar radius in R⊙) (Peterson 1963, Mukai and Yamamoto 1979). Infrared observations (Peterson 1967, MacQueen 1968) show infrared intensity enhancement at arround 4R⊙. We expected some enhancement of intensity even at optical wavelength, and tried to observe that. Since coronal light at 4R⊙ and further away is much fainter, can be only observed during a limited minutes of total solar eclipse, and is fainter than that of sky background from ground-level, we introduced some new ideas for our observation.

To reduce sky background light, observational instruments were launched at the altitude 30 km using a B15 balloon. For the guiding system, solar image was continuously sent to the ground-based station within a limited telemetry capacity. To reduce variation of sky background, two dimensional detector with short time constant was intended to be used. At the time when we started this project in 1978, a SIT camera was the most high sensitive and reliable one with a proper cost (Isobe et al 1980). Since 30 frames per second which make 10^8 data in 300 seconds for our observation were expected to be obtained, video recorder was introduced on board. During the observation, we rotated two wheels, one is a polarizer fixed at 8 positions one by one in a time interval of 1.8 seconds and the other contains four filters sitting at each position in a time of 15 seconds. To identify some fixed frame from very large number of frames, frame counter is given in each frame. Since dynamic range of the video recorder is less than 100, enhanced mode was applied for the observation in the outer faint region.

Here, we will show new technologies introduced in this observation for data acquisition and recording system.

2. Treatment of video signal

Our SIT camera introduced in this observation of solar eclipse in Indonesia has a standard system with NTSC. Two sequences of data acquisition were adopted; one is recorded in analog way on video tape on board and the other is that fixed 13 lines in a frame in each 1.8 seconds were transfered into digital data and sent to the ground-based station by PCM mode for recording on tape recorder. Both recorded data include several informations such as frame number, polarizer position, house keeping data, and so on.

2-1). Adopted video recorder

For balloon observation, we should adopt lighter and smaller video recorder which can be remotely operated. When this project was completely fixed in 1981, a video recorder of SL-F1 produced by Sony Co. Ltd. with a weight of 4.2 kg was one of the best candidates. A test of recording and reading was carried out by looking a uniform surface light source by HITACHI H-62SITV and HAMAMATSU MODEL 1000 Karnicon ITV for 30 seconds. Signal of Horizontal synclonization is taken to be 0 volt and relation of input and output voltage is given in figure 1. Upto 1.4 volt, a linear relation is seen, which is satisfactory for our observation. Noise level is about 20 mV and therefore a dynamic range of 50 (= 1V / 20mV) is obtained.

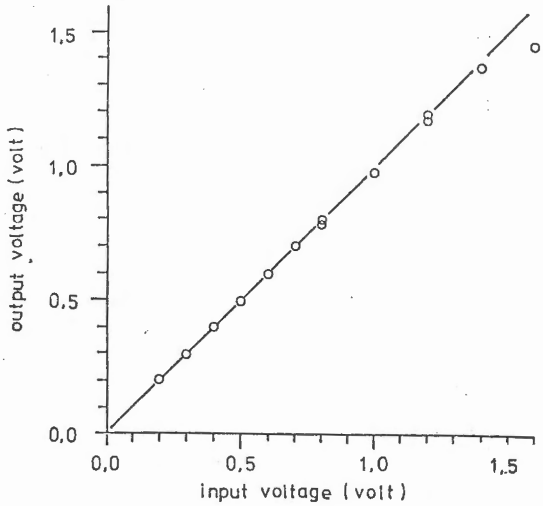


Figure 1. Linearity test of input and output voltage for the video recorder.

2-2). Telemetry of data

Since our telemetry ability was very limited in 9600 bits per second because of the reduction of weight of gondola, all data could not be sent to the ground-based station. Moreover, there were some percents of probability that video recorder would fail to record the data and to be recovered. Therefore, small fraction of data were sent. Data of 13 lines in a frame in each 1.8 seconds were chosen, 128 data points in a line were holded in equal interval and each data was transfered into a digital data with 8 bits in 0.4 micro-seconds through an A/D converter. These data were stored in a frame memory of 16 K Byte. After recording data in a frame, the data were transmitted to the graound-based station in the following 1.8 seconds.

2-3). Enhancement of dynamic range of video recorder

Dynamic range of signal recorded on video recorder is about 50, but a SIT detector has much larger dynamic range. To observe wide range of coronal intensity from 3R⊙ to 10R⊙, two kinds of frames with different enhancement of signal from the SIT camera were recorded one by one.

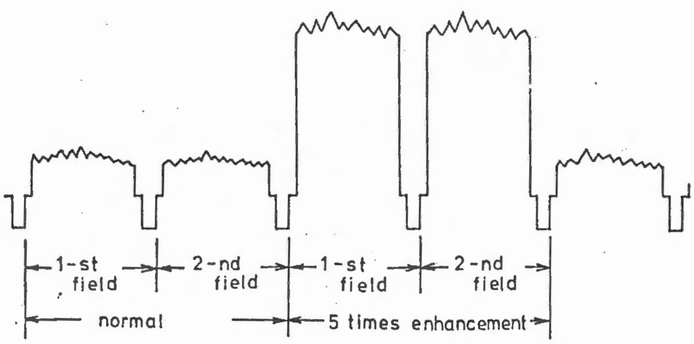


Figure 2. Sequence of frame.

The first one was normal video signal and the next one was 5 times enhanced signal. By this way, images of not only inner bright part of corona but also outer faint part were able to be recorded in a dynamic range of video recorder.

2-4). Pulse for frame identification

Not only video signal but also sound signal are able to be recorded on video tape, and therefore we wrote PCM digital data of 2700 bits per second for infrared observation on sound track (Maihara et al 1985). Moreover, we added one pulse just in front of each horizontal line as shown in figure 3. Since one frame has 128 lines, 128 pulses could be written in the frame, but 96 pulses for 12 data with 8 bits were written. All data are shown in table 1. These data were written on every frame, that is, 60 sets of pulses per second were recorded on a video recorder. When we read data on video recorder, these 96 bits data were compared with a fixed set of values defined by manual way, and the frame which has same identification pulses was transfered into the Hamamatsu frame memory C1901-2.

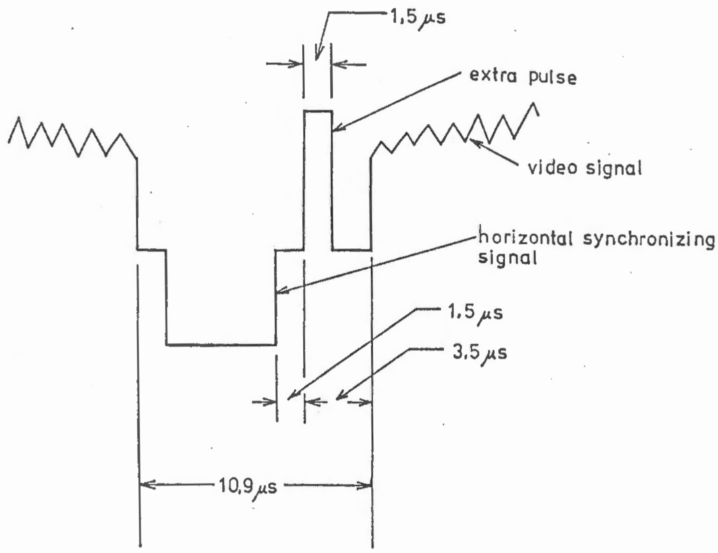


Figure 3. Location of extra pulse giving a data of frame identification.

2-5). Data transfer

Data recorded on frame memory on board was reduced by on-board computer into two modes. Mode 0: During solar eclipse observation 128 x 13 data in fixed 13 lines on one frame in each 1.8 second were transfered to the ground-based station in the following 1.8 seonds. Mode 1: A fixed intensity value is given, and if intensity value at each pixel is higher or lower than that value, 1 or 0 value is given. Then, coordinates where this value varied from 0 to 1 or from 1 to 0 were transfered successively. By this mode, we can send two images per second. Since field of our telescope was 5°x 5° which corresponds to 128 pixels x 128 pixels, a diameter of solar image corresponds to 13 pixels. Coordinates of 13 lines at maximum were continuously sent during partial solar eclipse and then we could know telescope orientation.

2-6). Format of transfer data

Format of transfered data during solar eclipse is shown in figure 4. Two bytes of video SYC data come first, and 11 bytes of house-keeping data follow. Then, 1664 data are recorded.

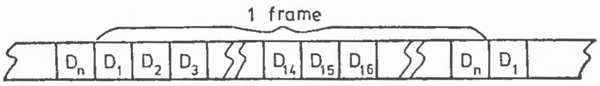
Table 1. All data given by extra-pulse on video recorder.

Channel	Items
1	Video Syncronization
2	Frame counter (high bits)
3	Frame counter (low bits)
4	Position of polarizer
5	Position of magnetic sensor
6	Position of shutter
7	Voltage of electric supplier
8	Azimuth of solar sensor
9	Elevation of solar sensor
10	Brightness of solar sensor
11	Positions of filters
12	Status (8 items)

Status	Items
1	SIT field: 1st field or 2nd field
2	SIT gain
3	Data transfer mode 0: ON or OFF
4	Data transfer mode 1: ON or OFF
5	Data transfer mode 2: ON or OFF
6	Evacuation vulve: ON or OFF
7	VTR recorder: Start or Stop
8	Command: Mode 1 or 2

3. Reading of recorded data

Our observational gondola was flying at altitude of 30 km and at place where duration of total solar eclipse was 220 seconds. We observed only in 140 seconds because we lost time to open shutter safely and to adjust instruments. Each frame which was interlaced and therefore has 256 x 128 pixels was successively recorded in 1/60 seconds. Normal intensity frame and 5 times enhanced intensity frame were recorded one by one in every 1/30 seconds. For one polarizer position, we observed in 1.7 seconds and 0.1 second was used to rotate the polarizer from one position to the other. After a complete rotation of the polarizer in about 15 seconds, filter was changed one by one out of 4 filters. Therefore, we were able to observe two complete sets of polarization observation for each filter band.



D_1 , D_2: SYNC data

$D_3 \sim D_{14}$: house-keeping data

$D_{15} \sim D_n$: $n \geq 128+14$ transfer time=0,15sec for MODE 0

$\geq 1664+14$ transfer time=0,17sec for MODE 1

$\geq 1664+14$ transfer time=0,17sec for MODE 2

Figure 4. Sequence of data transfered.

Total number of observed data on the recorded video tape was 256 (pixels) x 256 (lines) x 30 (frames per second) x 140 (seconds) $\sim$ 3 x 10^8. Since this number is too large, we tried to make these data compact using an computer with 16 bits double frame memories which were newly developed by the Hamamatsu Photonics Co. Ltd. in 1983. We gave data of polarizer position and filter position to the computer manually, and these data were compared with pulses for identification in each frame as shown in figure 3. When both data fitted each other, data of 15 frames with normal intensity level and 5 times enhanced intensity level were successively added in each frame memory. After this process, display of lower 8 bits data shows intensity contour map.

During total solar eclipse, signals on 13 lines in a frame in each 1.8 seconds were converted into digital data on board and transfered to the ground-based recorder. Therefore, these data did not suffer noise effect of video recording and reading. We compared these data with data recorded on video recorder in analog way and read by the computer with double frame memory, and it is found that there are no differences in noise level between them. From this result, the video recorder used in this observation worked nicely even at low temperature and low air pressure.

By the comparison between single frame and 15 times superposed frame data, we found that noise level of superposed one was reduced by $\sqrt{1 / 15}$ to that of single one, which show input noise depends on statistical fluctuation.

4. Calibration of data

To refine the data, following procedures were taken. Before launching, we observed uniform light source whose absolute intensity was measured, and obtained the data of sensitivity from one pixel to the other. A grid pattern was also observed to correct distortion of frame.

After these corrections, contour map of polarization degree and its position angle was obtained by superposing 8 frames at 8 polarizer positions. This process was easily carried out because pointing accuracy of observational gondola obtained by using flying wheel technique was better than 1 minute of arc (about 0.2 minutes of arc) which corresponds to 1/3 of line interval. Since we intended to make absolute intensity observation, automatic gain control system used for commercial instruments was removed.

5. Conclusion

In this observation, we tried to get very faint image of F corona during total solar eclipse under a condition of quick variation of sky background. Therefore, a balloon, by which observational instruments could reach to altitude of 30 km but which should be operated by remote control, was introduced. These claim us many engineering difficulties, but our system studied in a long period and used in this experiment worked nicely. Then, we could find a good astronomical results, that is, dust surrounding the sun shows high concentration in a ring region (Isobe et al 1985a).

If we start this project from now, we have a variety of system not only SIT and CCD but also PIAS (Photon Counting Image Acquisition System) developed by the Hamamatsu Photonics Co. Ltd. (Isobe et al 1985b). We have intension to develop our system to combining new detector for further observation.

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Optical Coronal Polarization and Solar Dust Ring

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Abstract

On June 11, 1983, an observation of the outer solar corona at Jawa island in Indonesia has been carried out at 30 km altitude using a B-15 balloon. At the optical wavelengths of 5925A, 5965A, 7200A, and 8015A, polarizations in a field of $5^\circ \times 5^\circ$ centered at nearly the sun were obtained and contour maps of them are shown in the figures. These data are compared with different kinds of previous observations and theoretical calculations concerning to F corona and interplanetary dust grains. Then, enhancement of polarization degree in the region near ecliptic plane at the solar distance of 4 R⊙ to 5 R⊙ is interpreted by enhancement of dust grains distributed in a ring surrounding the sun like a doughnut. This conclusion is consistent with infrared observations including the one obtained by Maihara et al (1985) who launched their instruments on the same gondola with our instrument.
Key words: F-corona, Interplanetary dust, Solar dust ring.

1. Introduction

There are many observations concering to interplanetary dust grains such as observations of zodiacal light, in-situ measurements by satellites, and lunar microcrater counts (see review papers of Blackwell, Dewhirst, and Ingham 1967, and Leinert 1975), which gave some ideas on grain materials, size, shape, and distribution in the solar system. However, there is still no concrete model for interplanetary dust grains, although it is very important to answer these questions for the study of our solar system. Additionally to the previous observations, it is very useful to add informations on thermal properties of dust grains. For this purpose, one should observe the region where dust grains start to evaporate because of heating by solar radiation. Infrared observations (Peterson 1967, MacQueen 1968, Mankin and MacQueen 1974) showed that there are enhancement of infrared radiation at the solar distance of arround 4 R⊙ and 10 R⊙, where dust grains are heated and start to evaporate.

To observe these evaporating grains, we made an observation of solar corona at four wavelengths during the total solar eclipse on June 11, 1983 in Indonesia. Observational techniques are shown in section 2 of this paper and in a paper by Isobe et al (1985), and reduction method of data in section 3. Our result is compared with other optical observations and with theoretical calculations in sections 4 and 5. In section 6, we concluded the existence of solar dust ring and discuss some problems relating to solar system.

2. Observation

Coronal light of the sun is composed of the sunlight scattered and diffracted by two components of elements, such as coronal electron and interplanetary dust. We call them K corona and F corona, respectively. At the inner region of corona, intensity of K corona is much higher than that of F corona, but relative intensity of F corona to K corona normally increases with distance from the sun and is much larger than 1.0 at the region outer than 3.5 R⊙ except the region with coronal stream (for example, see Van de Hulst 1953). Fortunately, since the distance estimated by model calculations (Mukai and Yamamoto 1979) and observed in infrared wavelength (Peterson 1967), where interplanetary dust begins to evaporate and is blown out, is larger than 3.5 R⊙, there is high possibility to catch F coronal light

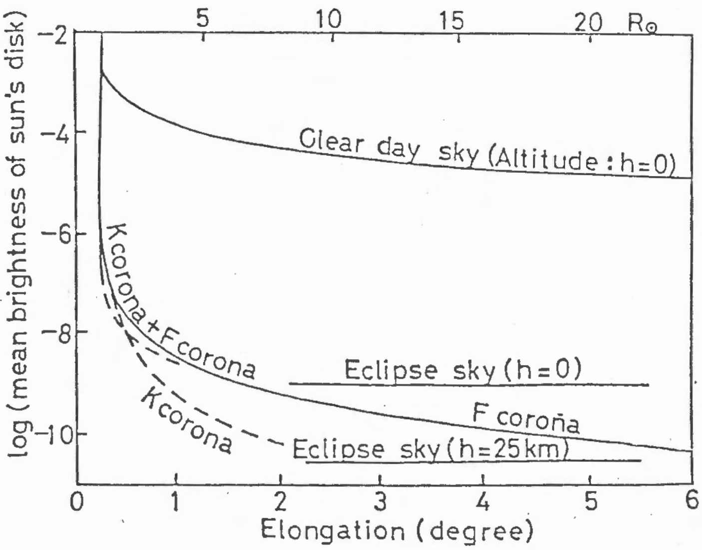


Figure 1. Schematic brightness distribution of the corona and sky after Saito (1959)

at the region, where dust concentration is enhanced, instead of K corona. However, brightness of F corona at these region is much fainter than skybackground light even at the time of total solar eclipse. To reduce the skyback-ground light, observations should be carried out at high altitude. Brightness distribution of various components depending on the distance from the sun is given in figure 1. A photograph taken by Mr. Anzai (Kyoikusha Co. Ltd.) at the solar eclipse near Bolobyudol in Indonesia on June 11, 1983, using image intensifier and photographic camera shows bright background light scattered by terrestrial atmospheric dust grains and molecules. In our observation of solar corona, observational instruments were launched at the altitude of 30 km using a 15000 m^3 balloon. General descriptions of the balloon and its launching are given by Tanabe et al (1984) and those of infrared instruments are given by Maihara et al (1985b). To reduce variation of skybackground, to have a wide field of $5^\circ \times 5^\circ$, and to give supplemental pointing information to our optical and infrared telescope, an SIT camera with two dimensional and short time constant detector was used. Details of data acquisition for the observational data and house-keeping data are given in the paper by Isobe et al (1985). Schematic diagram of arrangement of optical telescope, video recorder, and detector is shown in figure 2. An SIT TV camera has a dynamic range of 10^3. Therefore, to reduce an effect of bright light from the inner corona, an occulting disk with a radius of 3.5 R⊙ was settled. A transparent glass plate was placed with an inclination of 45° to the optical axis and alluminized in a cetral elliptical region correspoding to a circle with a radius of 3.5 Ro at focal plane. Unfortunately, this has created large instrumental polarization as shown in figure 3, but during digital data reduction processes this effect was subtructed in an accuracy of one percent of polarization degree. During the observations of 140 seconds, we rotated two wheels; one is a polarizer wheel fixed at 8 positions in one rotation one by one in a time of 1.7 seconds and the other contains four filters sitting at each position in a time of 15 seconds. Then, we have two complete sets of polarization observations at four wavelengths. Effective

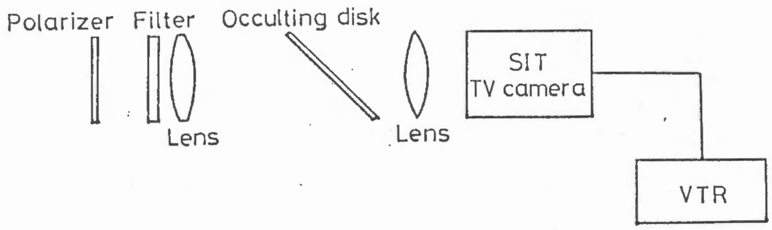


Figure 2. Schematic arrangement of optical telescope and video recorder.

Table 1. Characteristic parameters of four filters used for our observation and intensity ratio expected.

wavelngth	transmission	half width	relative intensity[1]	scattering efficiency[2]	relative intensity[3]
5325 A	88 %	250 A	2.76	1.87	1.14
5965 A	86 %	260 A	2.51	1.68	0.97
7200 A	75 %	400 A	2.09	1.38	0.87
8015 A	88 %	370 A	1.70	1.25	0.69

1) relative intensity of the sun.
2) scattering efficiency of small particle.
3) relative intensity expected to be detected.

wavelengths, half widths, and peak transmissions of four interference filters are given in table 1. A video recorder was also on board and all observational data was recorded, since number of two dimensional observational data was too large about 10^8 data to be sent to the ground-based station by our limited telemetry system at the observational site. However, dynamic range of our video recorder is about 50, and it is not enough to record all output signal from the SIT TV camera. Then, we treated output signal to have normal signal for one frame and 5 times enhanced signal for the other frame one by one. This made dynamic range 5 times high. To refine signal to noise ratio, data from 15 frames are added for each filter position, each polarizer position, and each signal mode. All instruments worked well except telescope pointing. We had a shutter wheel fixed at three positions. At one position, all light is shut and this mode was used before eclipse in order to protect the detector from bright sun light. During the total solar eclipse, open mode was used and then all light passed through without obscuration. During partial solar eclipse, neutral filter with density about 6 was inserted and we could moniter the solar image on the ground-based moniter TV obtained through the SIT camera. We had planned to make pointing of telescope by a geomagnetic sensor during total solar eclipse, which could be used for short minutes because our gondola moved continuously. Therefore, just before the total solar eclipse, we tried to keep manually the sun at the center of occulting disk, but we failted to do so in about 10'. This pointing error caused severe saturation effect to the TV frame by the bright light of inner corona (figure 4).

3. Reduction

All video data were transfered to digital data using a computer with 16 bits double frame memories developed by the Hamamatsu Photonics Co. Ltd in 1983, which was kindly made available for us. During the recording of observational data at the solar eclipse, one pulse just in front

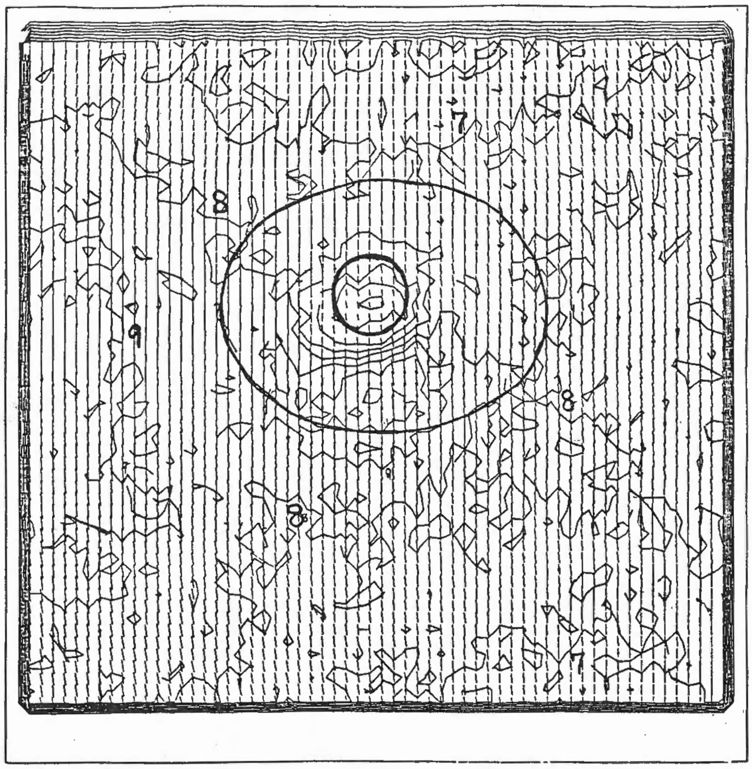


Figure 3. Contor map of instrumental polarization obtained by giving artificial non-polarized light through the same optical system for the observation. Polarization degree for each contour line is given in the figure in a unit of percent. Large elliptical ring is an area of occulting disk and small circle is the position of the sun at the begining of observation. Inside the elliptical ring, polarization degree is large because of aluminization. Vertical bar shows polarization degree and its position angle which is parallel each other as expected. This instrumental polarization was corrected.

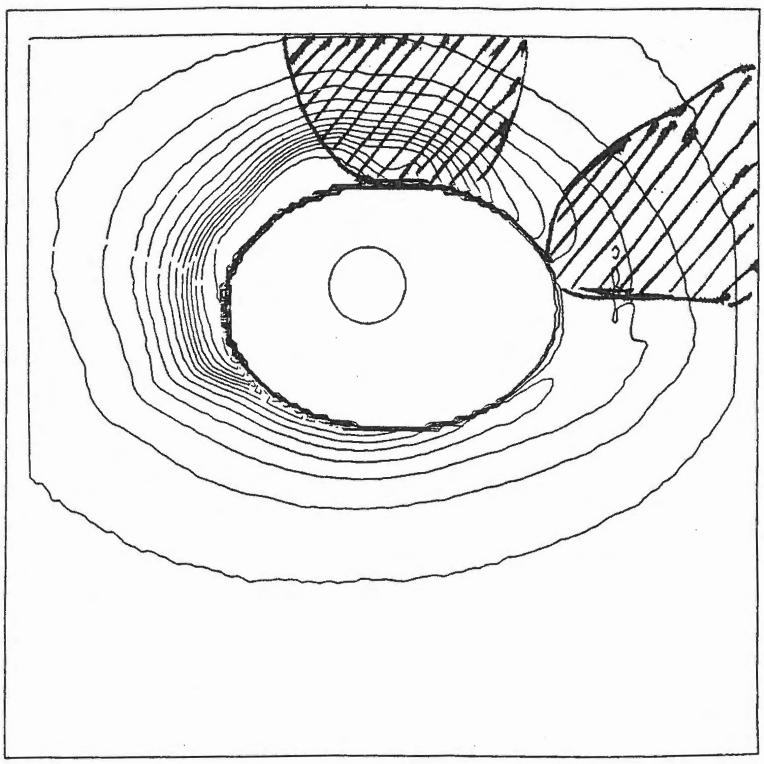
Figure 4. An example of TV frame at a wavelength of 7200 A. A part of occulting disk is seen as a dark casp. Since the disk has density of about 2, inner bright corona is seen through the disk. The position of the moon is a dark dot in the central region. Because of pointing error in 10' to the upper left direction, saturation effect appears at the upper left area of TV frame. This is a picture of 5 times enhanced mode and effect of blooming is also seen.

of each horizontal signal line was added to give various house-keeping data in which positions of polarizer and filter were include for frame identification. When we read data by the computer from the video tape, these data were compared with a fixed set of values given manually from key board, and the frame which had same identification pulses was transfered into the frame memory. Each analog signal from the video tape was transfered into a digital data with 8 bits, and 15 data from successive 15 frames with same filter and polarizer positions were added. These processes were carried out for both normal and 5 times enhanced modes, and data after carrying out these processes will be used for the further reduction. Since our gondola was controlled by flying wheel, drifting motion of telescope was less than 4'/minute (Koma et al 1985), and therefore position difference on the detector pixel of the solar corona between 15 frames was less than 1/10 of pixel size which is negligibly small for our later discussion. 256 x 256 data was obtained in a field of 5° x 5° for each filter position and each polarizer position, and in total, 256 x 256 x 8 (polarizer positions) x 4 (filter positions) x 2 (rotations of filter wheel) = 4×10^6 data were prepared for the further reduction shown in this paper.

An example of data for a frame is shown in figure 5a and its intensity contour map after applying noise cleaning shown in the next paragraph is also in figure 5b. Position of the region where the effect of occulting disk appeared on focal plane is shown by an ellipse. The center of solar (lunar) position is inside the ellipse. By the effect of gondola drift, the position of the sun moved with a rate of 4'/minute in the field for both azimuth and elevation from the beginning of observation to the end. By the error of pointing as explained in the previous section, the position of the sun was not the center of the occulting disk but sifted to upper (south) left (west). Therefore, bright light from the inner corona made saturation effect at this area, and made two ghost images at two area shown in figure 5b, which were realized to look carefully at the video moniter TV during a movement of filter wheel. All of these made image in figure 5a somewhat curious.

In figure 5a, one can easily see many shot noise produced during recording on board and reading by the computer. To reduce these spiky noise, we employed noise cleaning method and median filtering (Pratt 1978, p.319 and p.330). However, no meaningful difference was found between both methods. With regard to computation efficiency, one dimentional median filtering is preferable. Therefore, median filtering was adopted as noise suppression method throughout this paper. One dimentional median filtering was operated horizontally and the vertically to each noisy image. The length of window of the median

Figure 5. An example of frame before noise cleaning at the wavelength of 7200 A (upper photograph), and its contour map after applying noise cleaning (lower figure). Contour lines inside occulting disk are removed. Two areas suffering ghost images are shown by hatching. Contour is drawn in arbitrary unit.



filter was chosen to be three (or five for images with high noise level). A mean filtering with a window of 2 x 2 was done after the median filtering. Figure 5b shows the noise suppressed image of figure 5a.

To correct non-uniformity of detector sensitivity of our SIT camera, and the effect of instrumental polarization by the effect of occulting disk, observed data for unpolarized light (figure 3) was used at each polarizer position.

Since output video signal contains bias, one should subtract bias value for each frame. After the subtraction of this bias, ratio of output counts of normal frame to that of 5 times enhanced frame should be 1/5. This was so in an accuracy of a few percent except the region of central bright part and outer faint part. At the outer part, output count for normal frame was very low and suffered noise effect, and therefore data of five times enhanced frame are used. Since dynamic range of video recorder is an order of 10^2 for single frame, saturation level above 2000 for 15 times multiplied frame is in actual case, and therefore in the region where output counts for 5 times enhanced frame is greater than 2000, data of normal frame are used.

At the present stage, any absolute calibration of intensity scale has not been carried out. Comparison of relative intensities between our result and Saito and Hata's result, both of which were observed at the similar phase of solar cicle, has been carried out and we find a fairly good linear relartion between them. 8 images were taken by rotating a polarizer in a interval of 45 counter-clockwise successively. Then, polarization degree and its position angle at each point was calculated. Figures 6a to 6d show distributions of polarization degree, and polarization degree and its position angle for each 5 data point in both vertical and horizontal lines is shown by a line, length and direction of which denote degree of polarization and direction of electric vector, respectively. Polarization vector should be perpendicular to the radial direction from the sun except the region suffering ghost image, since coronal light is light scattered by coronal electron and interplanetary dust. Therefore, it is clear that the most of vector shown in figure 6 satisfy this condition, and our observational data are much confident.

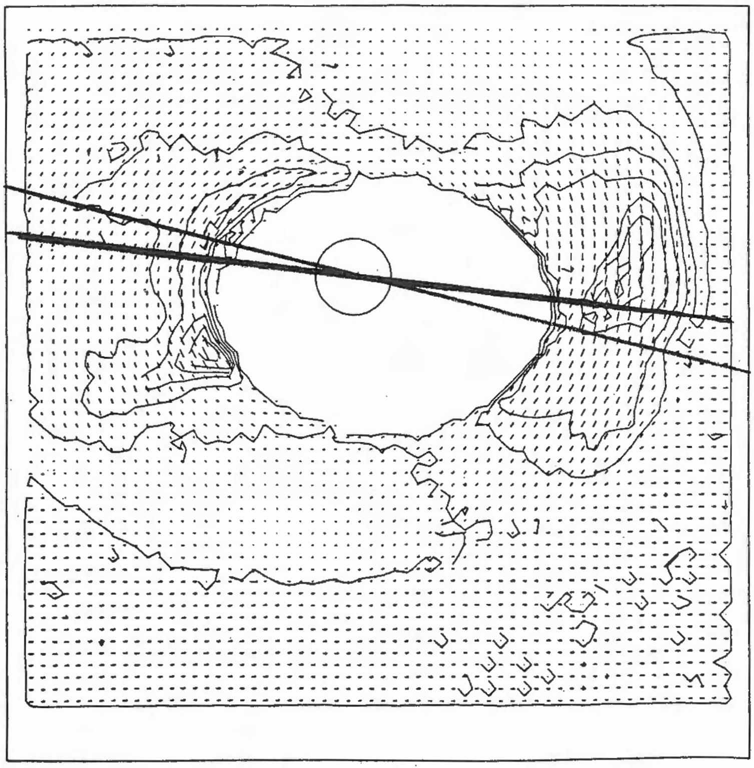


Figure 6a. Contour map of polarization degree. Contour unit is 5 percents. Ecliptic plane and solar equator are shown by thick and thin solid lines. North is down and west is left. High polarization region lower left from occulting disk located on a coronal stream seen on figure 5b and photograph of the inner corona. Positions of the sun and occulting disk are shown by circle and elipse, respectively.
One should mind that at the right region of high polarization there is some effect of ghost image. Polarization at about 4 Ro on ecliptic plane is rather high.

Figure 6b. Same as figure 6a for wavelngth 8015 A but for 7200 A. Figure includes saturation region at upper left just outside of occulting disk where polarzation vector is not perpendicular to the radial line from the sun.

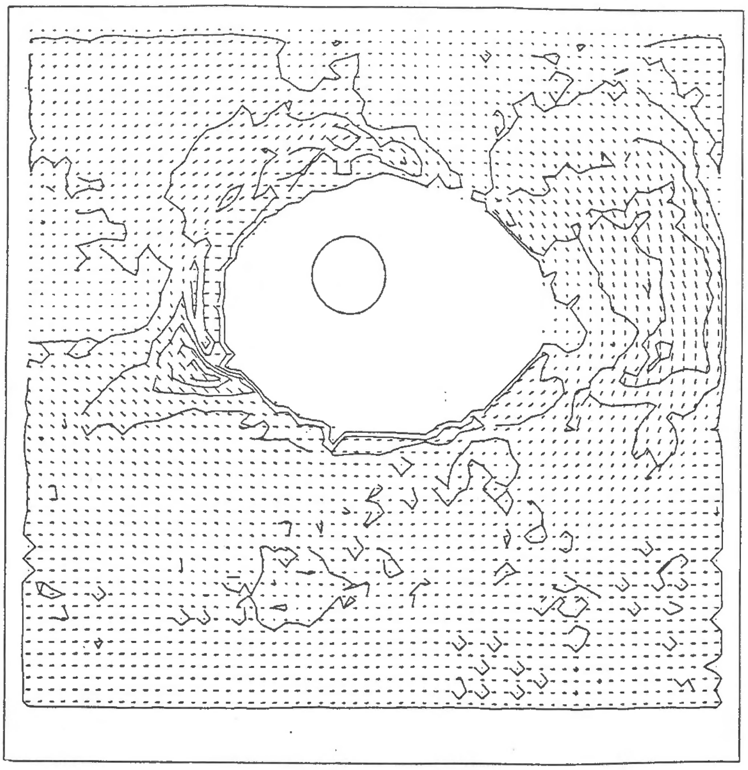
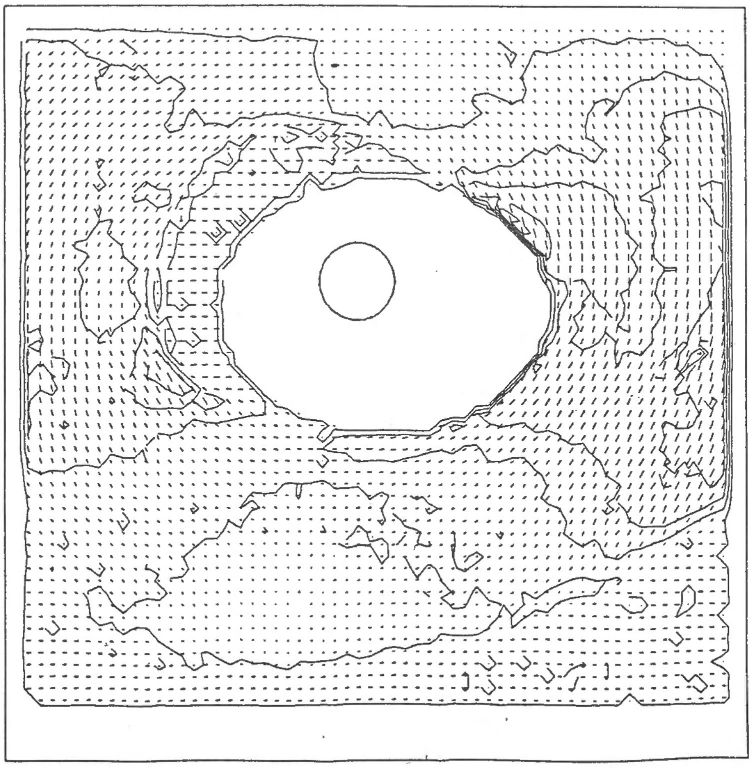


Figure 6c. Same as figure 6b but for 5965 A. Saturation region is much wider than that in figure 6b, because of high surface brightness at this wavelength



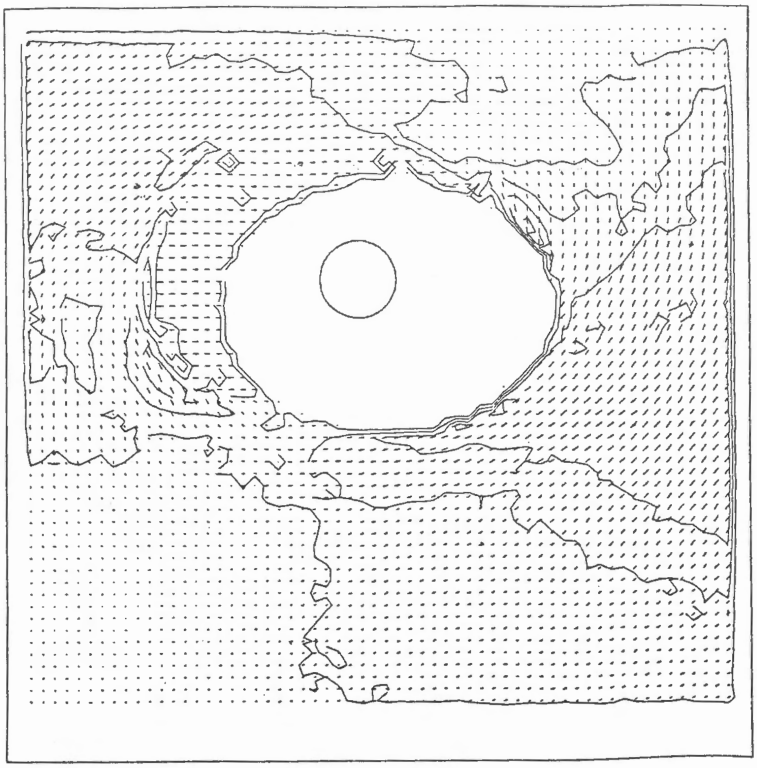


Figure 6d. Same as figure 6b but for 5325 A. Saturation region is much wider than that in figure 6c, because of high surface brightness at this wavelength.

4. F corona and K corona

The scattered sunlight in the solar corona is composed of dust scattered component (F corona) and electron scattered component (K corona). It has been difficult to separate two components in observed corona. Only way to separate them is to observe depth of Fraunhofer lines in coronal spectrum and to compare it with depth of solar spectrum (Blackwell and Petford 1966). In our observation, total intensities of both F and K coronal components at four wavelengths were obtained, and therefore, no information on relative proportion of F and K components was given. Van de Hulst (1953) collected data of F and K coronal components at the region of solar distance from 1 $R_\odot$ to 10 $R_\odot$ from several papers. Those show that component is brighter than F component at the region less than about 2 $R_\odot$, but is much weaker in 20 percents at that further than 3.5 $R_\odot$ except the regionof coronal stream. K component is due to scattering of the sun light by free electrons and show continuum spectra because of high kinetic temperature of free electrons. Therefore, it depends on column density of free electrons and scattering efficiencies as a function of scattering angle on the line of sight. Therefore, coronal intensity is strong near the sun because of high electron density there. F component is due to scattering by dust grains in interplanetary space and depends on their number density and phase angle. To estimate relative intensities of K and F components, it was assumed that polarization degree is 0 percent, because the most of grains are located far from the sun and have small scattering angle. There are many calculations (Röser and Staude 1978, Mukai and Yamamoto 1979) showing that temperature of dust grains is high enough to make them evaporate near the sun and dust free zone is produced. The size of this zone is found to be arround 4 R⊙ from their calculations. Then, one can expect that F component at the region further than 4 R⊙ has some degree of polarization caused by grains which scatter the sunlight with scattering angle arround 90°. Blackwell and Petford (1966) made an extensive observation of outer corona and obtained intensity and polarization of F and K components at the region further than 5 R⊙ at the total solar eclipe on July 20, 1963. Following their results, polarization degree of combined light of F and K components is from 8.7 % at 5 R⊙ to 3.6 % at 40 R⊙, and polarization of F component increases gradually from 0.05 % at 5 R⊙ to 2.8 % at 40 R⊙.

At the total solar eclipse on February 5, 1982, Saito and Hata (1964) made an observation of polarization at the wavelength 6200A and showed a distribution of polarization degree depending on solar distance. Following their results, polarization degree decreased from 1.5 R⊙ to 4 R⊙ to all direction from the sun is about 10 % at 5 R⊙ which is nearly consistent with the result of Blackwell and Petford (1966). Our result is shown in figure 7 which is consistent with the previous results except between 4 R⊙ and 5 R⊙ on ecliptic plane.

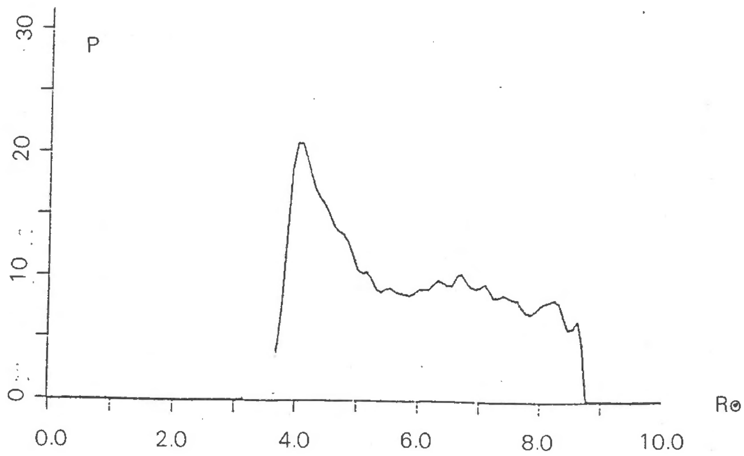


Figure 7. Distribution of polarization degree depending on solar distance on ecliptic plane (westward).

High value of polarization at the inner region of corona is caused by electron scattering with scattering angle arround 90° and therefore depends on electron density distribution. Because of slow decrease of electron density at the region from 1.0 R⊙ to 1.5 R⊙ on ecliptic plane, relative number of electron with scattering angle arround 90° to that with the other angle is smaller at the region of 1.2 R⊙ than that at the region of 1.5 R⊙ and then polarization degree at 1.2 R⊙ is smaller than that at 1.5 R⊙. However, polarization degree decreases depending on the distance from the sun because of increase of relative intensity of F corona to K corona (van de Hulst 1953). This explains clearly the results upto 3 R⊙ by Saito and Hata,

If dust grains scatter light forward, low polarization degree (actually 0 %) will be expected. This effect plays a role to reduce polarization degree at the region from 1.0 R⊙ to 4.0 R⊙. However, when dust grains scatter light with scattering angle arround 90°, the light is polarized in a range of 0 % to 60 % depending on refractive index, radius, and wavelength of dust grains (Hanner 1971, Isobe 1975). Therefore, one can expect that high value of polarization degree obtained from our observation at the region from 4 Ro to 5 Ro in ecliptic plane is caused by these types of dust grains with side scattering.

5. Interplanetary dust

It is well known that there are dust grains in interplanetary space. From different kinds of observations, there are different sizes of grains from sub-micron to mm (Leinert 1975, figure 24). In these range of dust grains, grains with size of some ten micron mainly contribute to the zodiacal light which is the scattered light of the sun by interplanetary dust grains. These grains with small radius spiral in toward the sun by the Poynting-Robertson effect. Then, grain temperature increases toward the sun depending on the distance from the sun and reach to evaporation temperature of dust grains which start to evaporate. Calculations by Peterson (1963) and Mukai and Yamamoto (1979) showed the distance of evaporation is at arround 4 R⊙. Infrared observations by Peterson (1967), MacQueen (1968), and Maihara et al (1985) showed enhanced emission by heated dust grains at arround 4 R⊙, confirmed existence of dust free zone inside about 4 R⊙, and suggest also enhancement of number density of dust grains in this region. Since infrared emission is thermal emission and strongly dependent on grain temperature, and grain temperature decreases depending on the distance from the sun, infrared observations could not tell how far such enhancement reaches to.

Our observation was performed at the optical wavelength and only light scattered by coronal electron and interplanetary dust grains is obtained. Therefore, our observation is not affected by grain temperature and gives informations concerning to all materials on the line of sight.

High value of polarization degree from 4 R⊙ to 5 R⊙ on ecliptic plane obtained by our observation is caused by these enhancement of dust grains in these region.

Giese and Grün (1976) showed the size distribution of dust grains from the measurement of in situ by the HEOS satellite and from lunar microcrater counts, and Grün et al (1976) concluded that density distribution of dust grains is proportional to $r^{-1.3}$ (r is distance from the sun) from particle impact observation. Leinert, Hanner, and Pitz (1978) reproduced intensity distribution of zodiacal light nicely by using these data. There, it is shown that interplanetary dust grains with size range of 10 micron to 100 micron mainly contribute to zodiacal light. Dust grains with these size range scatter effectively not only in visual light but also in infrared light. Bread (1984) estimated polarization degree dependent on elongation with a model of size and space distribution of dust grains. For the grains larger than 1 micron, calculated distribution of polarization degree is consistent with the observational result by Saito and Hata (1964) upto 4 R⊙, but is not with our result for the region between 4 R⊙ and 5 R⊙. In the region of elopngation smaller than 4 R⊙, F component comes mainly from scattering by dust grains at arround 0.5AU in visible light because of enhanced forward peak in scattering for these grains (Bread 1984). However, at the region between 4 R⊙ and 5 R⊙, one can expect to have additional light for the F component by dust grains located at the region with scattering angle arround 90°, since dust free zone is only upto 4 R⊙. Mukai and Yamamoto (1979) showed that interplanetary grains spiral in toward the sun but start to evaporate from 8 R⊙ depending on grain materal and radius and stay at the region between 4 R⊙ and 5 R⊙ for a certain period because of balance between gravitational force and radiation pressure force. Therefore, in these region, there is an enhancement of dust grains with size smaller than those in general interplanetary space. Both effects make observational polarization high at these elongation.

6. Distribution of dust grains

Dependence of polarization degree on scattering angle is a function of grain material and size, but polarization degree for forward scattering is clearly 0 % and is maximum arround scattering angle of 90°. Assuming 40 % of polarization degree at 90° for sub-micron grains which are abundant at the region between 4 R⊙ and 5 R⊙ and taking 10 % of polarization degree for F component obtained from observational polarization degree and intensity ration between F and K components given by van de Hulst (1953), relative amount of dust grains in the region between 4 R⊙ and 5 R⊙ to those in the other region on the line of sight is estimated to be an order of 10^2. This high value comes from the fact that scattering efficiency is very high for forward scattering compared with side scattering (Hanner 1971). Adopting generally accepted $r^{-1.3}$ dependence of number density distribution of dust grains with 4×10^{-23} g cm^{-3} at 1 AU (Leinert 1975), total amount of dust grains in the region between 4 R⊙ and 5 R⊙ with thickness of 1 R⊙ is about 10^{13} g. Since dust distribution surrounding the sun has ring structure like doughnut with 10^2 times enhanced density in this region, total amount of dust grains obtained from our observation becomes to 10^{15} g. This is slightly larger than that obtained by Maihara et al (1985) from infrared observation at the same total solar eclipse for our observation. Both results looks quite consistent, but the slight difference may originate in the fact that they adopt rather large grain size in their estimation which is not consistent with our polarization observation and with intensity distribution depending on elongation from ultraviolet observation (Koomen etal 1970), visual observation (van de Hulst 1950), and infrared observation (MacQueen 1968). We need further observations to fix which size of grains contribute in this region.

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INFRARED BALLOON OBSERVATIONS OF THE F-CORONA (I)
——INSTRUMENTAION AND OBSERVATION——

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ABSTRACT

Near infrared observations of the solar corona were made using a stratospheric balloon successfully launched by a joint team of ISAS, Japan and LAPAN, Indonesia. The near infrared instrument comprised of a four-wavelength band simultaneous photometer attached to a 16-cm Cassegrain telescope. With this photometric system surface brightness distributions of the coronal region were obtained at wavelengths between one and three microns during the totality. This report descirbes the details of the photometer together with observational procedures.

1. PHOTOMETER/POLALIMETER

The thermal radiation from the zodiacal dust cloud in proximity of the sun is expected to be observable in the near infrared region from 1 to 3 μm, since the temperature of the dust is supposed to be in the range between 1000K and 2000K. Such an observation, however, is possible only on the occasion of solar eclipse due to its faintness compared with the intense solar radiation, except for sophisticated corona-graphical equipments applicable to limited objectives. To make a rather extended and confident observation of such thermal radiation of the circumsolar dust cloud, we designed and constructed a near infrared multiband photometer capable of measuring spectral characteristics of the radiation especially at the position around 4 solar radii ($R_\odot$) from the sun.

The photometer is attached to a 16-cm Cassegrain telescope which is equipped with an automated scanning mechanism with an axis of cross-elevation. The telescope and photometer system is mounted on an elevation-adjustable table together with a high-sensitivity TV camera to get optical images of the outer F-corona. Details of the TV imaging system will be described in this volume by Isobe et al.

At the focus of the telescope of F/4, we installed a four-wavelength band simultaneous photometer as illustrated in Fig. 1. Detectors employed are 4-element PbS photoconductive arrays. For the 1.25 μm band (J-band), we used P1026 type of HAMAMATSU Co. with a one-stage thermoelectric cooler. For the three bands (1.65 μm : H-band, 2.25 μm : K-band, and 2.8 μm : L'-band), we utilized OTC-22S-8 type of OPTO ELECTRONICS, INC. with similar cooler elements.

The incoming telescope beam is devided into four foci by three beam splitters which are actually interference filters with band-pass or long-pass characteristics. In addition to the filter system, we placed a wire-grid type polarizer in front of the K-band detectors to get polarization at 2.25 μm. The overall response curves of each photometric band are presented in Fig. 2. The spectral response of PbS detectors is also shown in the same figure at a temperature of about -50°C sensed by thermometers attached to detector elements.

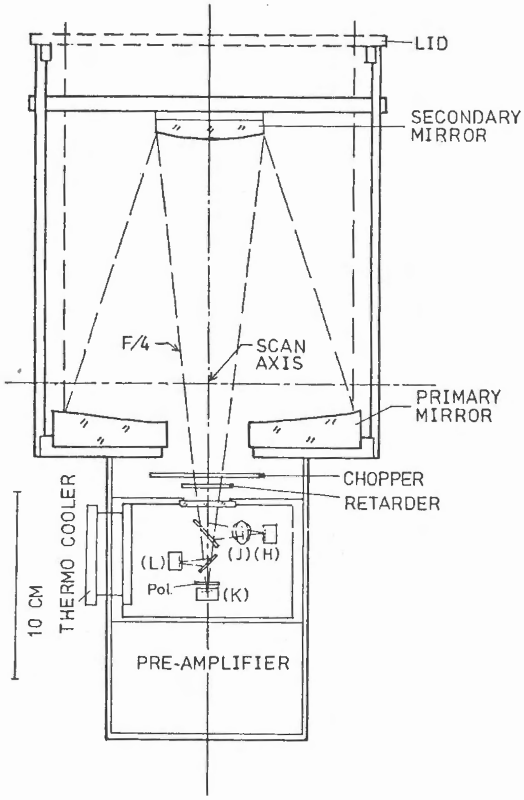

Fig.1. Near infrared telescope attached by a 4-band photometer with a polarimetric device at K-band.

The beam modulation is made by a two-blade sector chopper with the modulation frequency of 90~100 Hz. Next to the chopper, we incorporated a half-wave retarder which is continuously revolved at a rate of 0.3 Hz yielding intensity modulation with a period of about 1.2 sec when the polarized beam is introduced to the K-band.

Bias voltages applied to detectors are about 35 volts through load registers of 10 MΩ. Together with these bias circuits, 16 preamplifiers using LF444 type operational amplifier chips are placed in a box adjacent to the photometer room.

This system has an instantaneous field of view of $0.^\circ08 \times 0.^\circ08$ ($0.3\,R_\odot \times 0.3\,R_\odot$) and minimum detectable surface brightness of about

3×10^{-9} W cm^{-2} μm^{-1} sr^{-1} at each band.

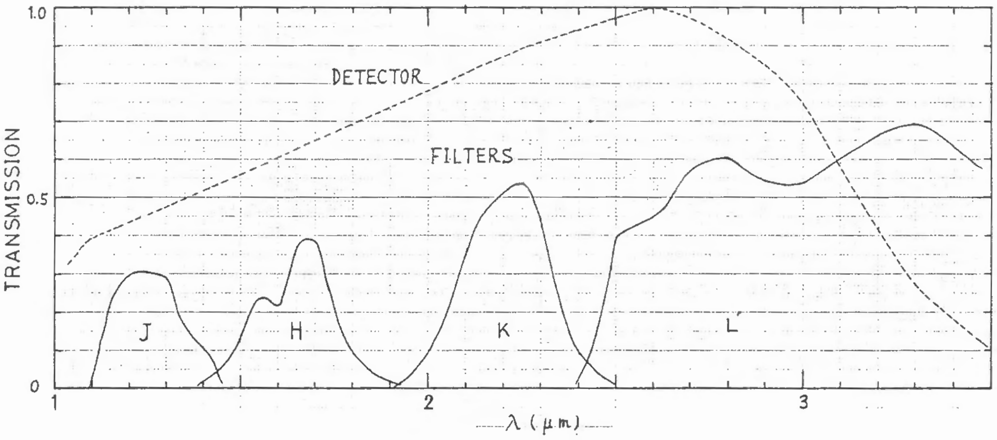

Fig. 2 Filter transmission curves of J, H, K and L' bands together with the detector responsivity.

2. DATA ACQUISITION

The blockdiagram of the on-board data handling electronics is presented in Fig. 3. All the data are transmitted to the ground monitor/recorder system via 1680 MHz radio waves through the PCM modulator shown in the figure. The number of analog channels are 23 and digital status of 8 channels are interspersed among the serial PCM train.

Since the K-band data requires fast time constant to follow modulated signal by polarization, the sampling rate of the K-band is 18 Hz, while the other photometric bands are transmitted by the rate of 4.5 data per second. Including 7 house-keeping data, 23 analog signals are converted to digital data via the 11 bit AD-converter.

A double-tone telecommand system is used to control telescope scanning, lid openning, calibration source lightening and thermo-cooler igniting.

All the data of 2.7 kbps is recorded in a cassette tape recoder on the ground.

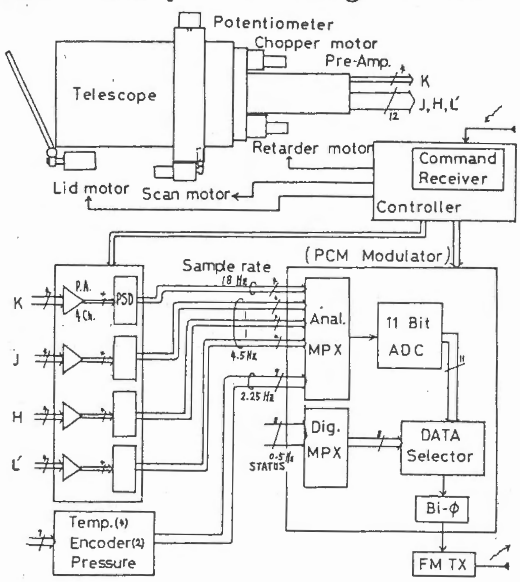

Fig.3. Onboard electronics diagram

3. OBSERVATION

Preparations and launch works will be reported in detail in the preceeding article. Hence here we describe briefly observational procedures and primary results by the instruments specified above.

Scannings along a line inclined to the ecliptic by 7 degrees were made for about 3 min during the totality within a 20 $R_\odot$ width around the sun. Excess emissions on the continuum coronal brightness were detected at 1.25, 1.65 and 2.25 μm when the scan crossed the ecliptic on the west side of the sun.

Fig. 4 shows the observed brightness distribution obtained by the detectors crossing the peak emission region at about 4 $R_\odot$. As shown here, the 1.65 μm (H-band) feature of the excess emission is most prominent.

To compare with the previous observations made at 2.2 μm (K-band), we presented the 2.2 μm profiles in Fig. 4. Our present data have less conspicuous excess at 4 $R_\odot$ than the excess features reported by Peterson (1967, 1971) and MacQueen (1968). Analyses and discussion will be presented in the following article.

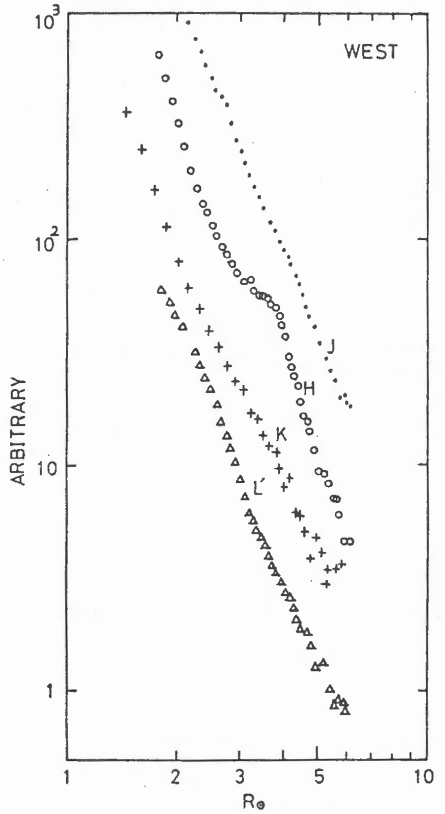

Fig. 4 (Upper)
Observed brightness distribution at each band on the west side of the sun.

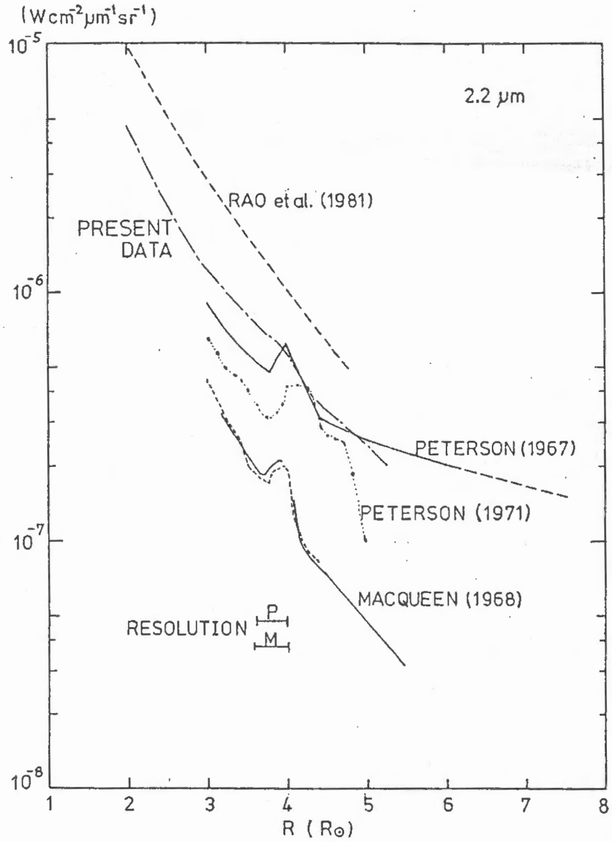

Fig. 5 (Right)
Comparison with the previous observations at 2.2 μm.

INFRARED BALLOON OBSERVATIONS OF THE F-CORONA (II)
—— THERMAL EMISSION OF THE CIRCUMSOLAR DUST AND POLARIZATION PROPERTIES OF CORONA——

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ABSTRACT

The surface brightness distributions in four near-infrared bands : at 1.25, 1.65, 2.25 and 2.8 μm, have been obtained in the inner to outer coronal region roughly along the ecliptic. Polarization at 2.25 μm has also been measured within about 3 $R_\odot$. Noticeable excess emissions superposed on the strong coronal background emission were recorded in the scan profiles at 1.25 and 1.65 μm at about 4 $R_\odot$ from the sun. From the observed spectral feature, we could attribute the excess emission to the thermal radiation of large olivine-like particles in the circumsolar dust cloud.

1. SPATIAL DISTRIBUTION

Near-infrared scanning observations at four photometric bands was made by small amplitude oscillation of telescope around the cross-elevation axis. The width of the scan was 5°(~20 $R_\odot$) and its rate was 0.05°/sec, which enabled one and half scans between 6 $R_\odot$ on the west side of the sun and 14 $R_\odot$

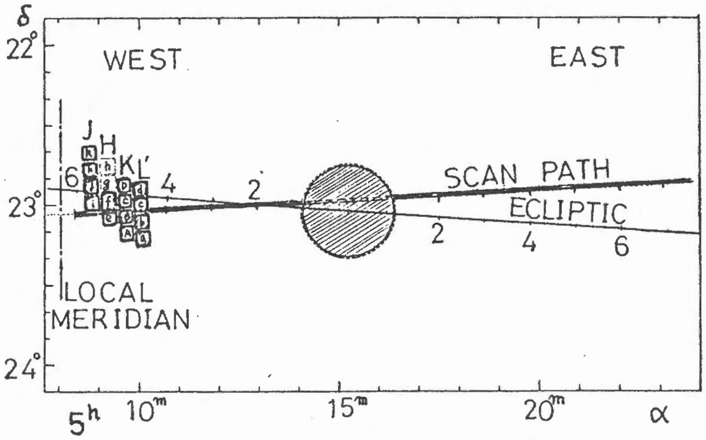


Fig.1 Scan path of the telescope beam and the projected focal plane array of detectors.

on the east side. The scan paths crossed the ecliptic plane on the west side at 4 R$_\odot$ with an inclination of ~7°. The configuration of the scan path and beam positions of each detector are shown in Fig. 1.

Before discussing on the spectral behavior of the surface brightness distribution of the corona, we shall comment on the spatial distribution of the excess component conspicuously observed at 1.65 μm (H-band). The excess component of the 1.65 μm band seems to extend from 2.8 R$_\odot$ to 4.5 R$_\odot$ with a small peak at around 3.8 R$_\odot$ in the west scan. On the east side as well, it shows an excess emission between 3.0 R$_\odot$ and 4.4 R$_\odot$ with the intensity considerably smaller. If we assume that the excess originates in an cloud of ring-like structure, and that the distribution is symmetric with respect to the sun, then we can get a rough sketch of the shape of the excess component in the form of contour map as in Fig. 2.

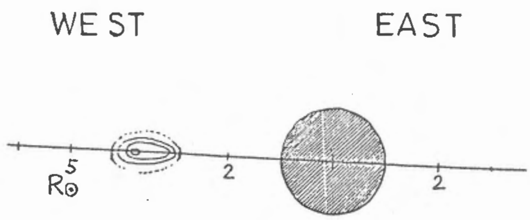


Fig.2. Spatial distribution of the 1.65 μm excess emission drawn by assuming its symmetry.

2. THERMAL EMISSION SPECTRUM

The brightness distributions in each band on the west side of the sun along the scan path are shown in Fig. 3. At 1.65 μm a definite excess over the smooth coronal background emission is recognized between 2.8 R$_\odot$ and 4.5 R$_\odot$ with a peak at 3.8 R$_\odot$. A weaker excess is also seen between about 3 R$_\odot$ and 4.4 R$_\odot$ on the east side, where the peak is also at about 3.8 R$_\odot$. The brightness of the excess component on the west side is 6×10^{-7} W cm^{-2} μm^{-1} sr^{-1}, while on the east side it being 2.2×10^{-7} W cm^{-2} μm^{-1} sr^{-1}. A relatively small but obvious excess

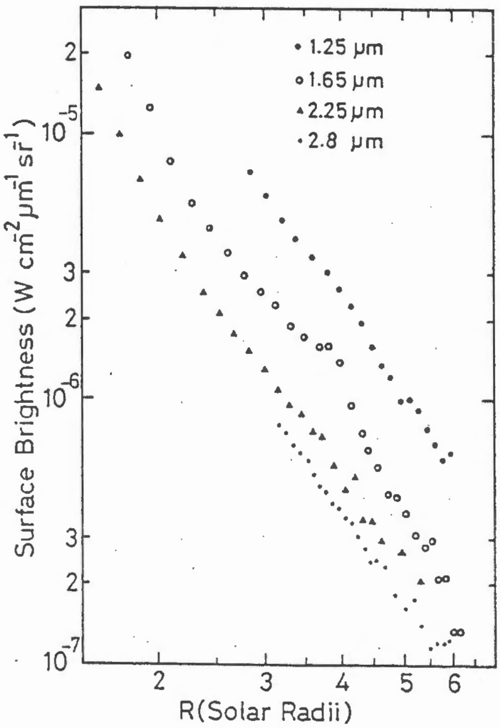


Fig.3. Brightness distributions of each band averaged over every 0.15 R$_\odot$.

emission is also seen in the 1.25 μm profiles from about 3.2 $R_\odot$ to 4.5 $R_\odot$ on the west side of the sun, obtained through a roughly identical scan path as that of the 1.65 μm band. The position of the peak is again at about 3.8 $R_\odot$, and the brightness of the excess component is 3.7×10^{-7} W cm^{-2} μm^{-1} sr^{-1}.

In the 2.25 μm band, an excess emission could be discerned at about 4 $R_\odot$ on the west side with its marginally detected brightness of the excess of $1.0 \pm 0.4 (1\sigma) \times 10^{-7}$ W cm^{-2} μm^{-1} sr^{-1}, roughly consistent with the previous observations by Peterson (1967) and MacQueen (1968). We found no definite excess component at the 3σ level of 1.2×10^{-7} W cm^{-2} μm^{-1} sr^{-1} in the 2.8 μm band.

In Fig. 4, we show a near infrared energy distribution of the excess component derived from the present observation together with the previous data at 1.65 μm and 2.2 μm. It has a maximum at 1.65 μm and drops off at both shorter and longer wavelengths, especially between 1.65 μm and 2.25 μm, differing significantly from the solar spectrum. Therefore, we argue that the excess emission component is not due to scattered light but is due to mainly to thermal radiation of the circumsolar dust particles with relevant composition that can produce such particular spectrum.

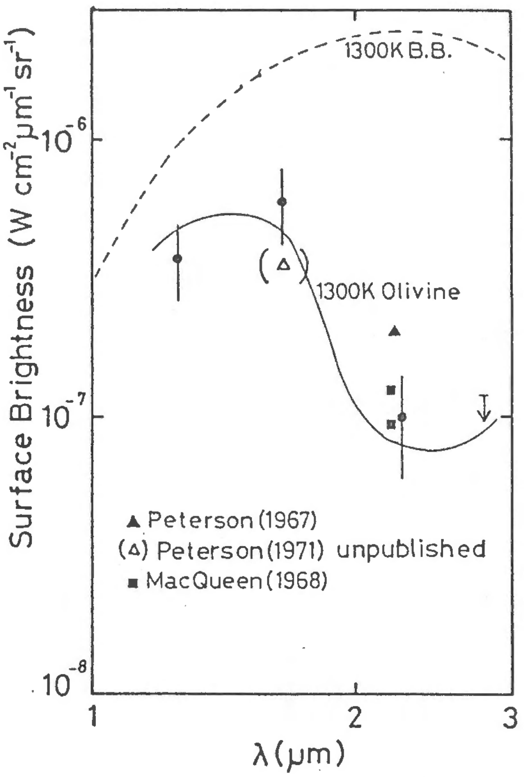


Fig.4. Energy spectrum of the excess emission component. Solid curve represents the thermal radiation spectrum of a 100 μm olivine particle with temperature of 1300 K.

A possibility that silicate grains such as obsidian particles are responsible for the near infrared excess just outside of the dust-free zone has been discussed by Lamy (1974). Mukai et al. (1979) have proposed a two component model of obsidian and graphite. However, the spectral features observed by us are not consistent with these material even if we consider the large uncertainty in the data at longer wavelengths. One interpretation we have so far envisaged is that the emission in question is accounted for by thermal emission from olivine particles of the order of 100 μm in radius at temperature of about 1300-1500K. Olivine possesses a strong absorption band between 0.8 μm and 1.7 μm, and hence is more emissive within this band. Smaller olivine particles are not favored because in that case intensity of scattered light overwhelms thermal radiation of such particles, making the spectrum appear solar. As an example we display the thermal emission spectrum of olivine with a radius of 100 μm and a temperature of 1300K in Fig. 3.

3. POLARIZATION OF THE CORONA

Near infrared polarization of the corona was also measured at 2.25 μm with four K-band channels. One of the primary data of polarization signal normalized by instaneneous intensity is shown in Fig. 5. As seen here, it is apparently difficult to get polarization degree in the outer region of the corona. Nevertheless we have obtained averaged data of polarization up to 2.8 $R_\odot$ using 4 detector channels.

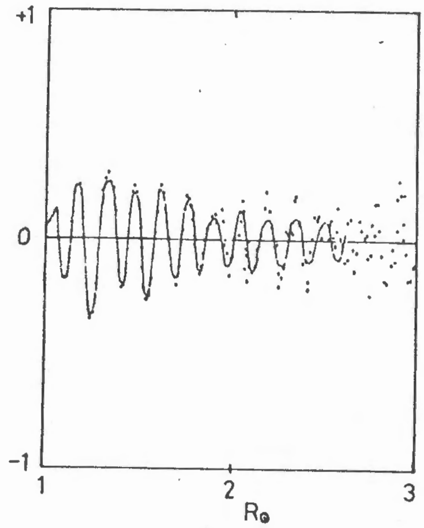


Fig.5. An example of polarization-modulated signal of the K-band.

The polarization degree of the two independent scans on the west side is plotted in Fig. 6. These observations measuring near infrared polarization of the corona must be the first ones ever made. As has been pointed out by Beard (1984), measurement of infrared polarization of the corona is important to get definite information of the size of interplanetary dust.

It is safely assumed that the observed polarization should originate only in the K-corona component, since the F-corona can be regarded to be non-polarized in the region of 1.5 to 3 $R_\odot$, while the K-corona having larger polarization of the order of 60% (e.g. Van de Hulst 1950). In this consideration it is easy in principle to make

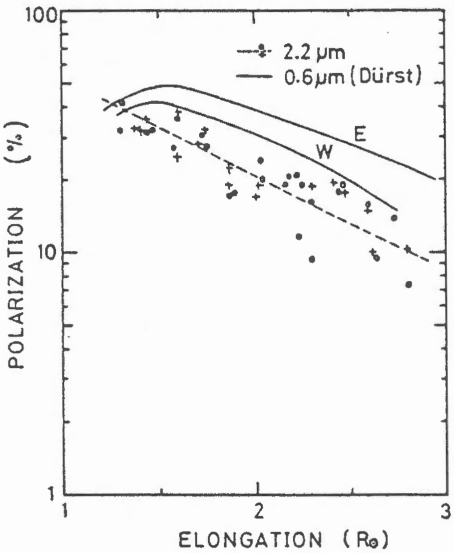


Fig.6. 2.25 μm polarization along the scan paths.

separation of the K-corona. Moreover as the Thomson scattering by electrons has no wavelength dependence, it turns out that we have get the K-corona brightness at the other wavelengths. Thus we can extract the F-corona profiles (west side) in each band as shown in Fig. 7. The spectrum of the F-corona in the near infrared region is quite indicative. In Fig. 8 (a) and (b), we show calculated curves for a model F-corona assuming the particle radius a=1, 10 and 100 μm. In this calculation, we adopt the spatial distribution of $r^{-1.1}$, letting the density equal zero inside 3.8 $R_{\odot}$. From these figures it is obvious that the particles must be as large as 100 μm in radius or even larger.

In the course of this calculation one can notice that, when we employ such large particles, the F-coronal light is largely contributed by dust located relatively far from the sun, namely with near-zero angle of scattering. This fact is just consistent with the supposition that the F-corona is virtually not polarized. It is

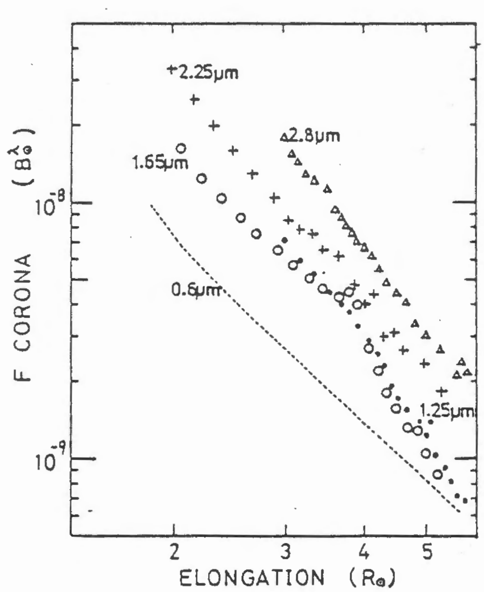


Fig. 7. Derived F-corona components. The 0.6 μm plots are of Dürst (1982).

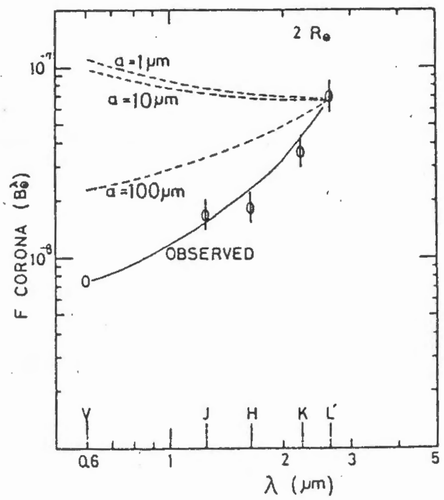
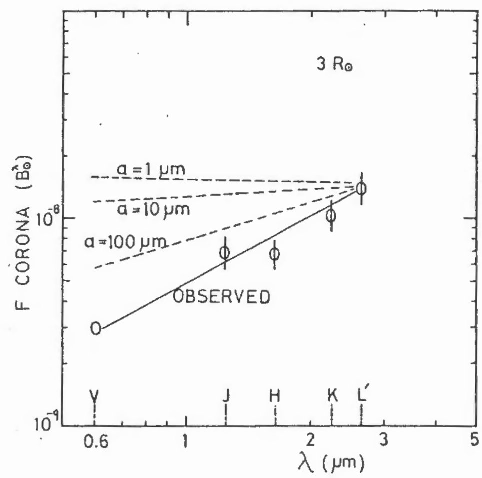


Fig. 8(a). Calculated spectrum of the F-corona by the Mie-theory at 2$R_{\odot}$.



(b) Same as (a) but at 3$R_{\odot}$.

also very important to note that the size spectrum in the region smaller than 100 μm in radius must be rather flat, i.e. the index of the power spectrum : $\gamma \lesssim 2$, when expressed as $a^{-\gamma}$.

4. DISCUSSION

The supposition that the circumsolar dust might be relatively large particles composed mainly of olivine is related to recent studies of interplanetary dust and its mineralogy as follows. Weiss-Wrana (1983), for intance, has shown that the principal properties of the zodiacal light are well represented by opaque irregular-shaped chondritic particles of the size range of 20 to 120 μm. The majority of stratospheric micro-meteorites, the so-called Brownlee particles (Brownlee 1979) exhibits opaque and black appearance and composition similar to C1 carbonaceous chondrite. It is in general known that extraterrestrial solids like stony meteorites contain olivine as a major constituent. Moreover, according to an experiment by Hashimoto et al. (1979) on the thermal metamorphism of C2 type carbonaceous chondrite, it has been demonstrated that the bulk of it becomes olivine when heated higher than about 1000K.

The infrared spectrum which we have observed can thus be understood as a result of the thermal metamorphism of zodiacal dust particles as they spiral down to the hot region of the circumsolar dust cloud around 4 $R_\odot$. Hence we get a consistent picture of the general interplanetary dust in terms of both the excess emission component by hot olivine and the F-corona spectrum implying large (~100μm) refractory and still opaque particles.

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STUDY OF SOLAR ECLIPSE EFFECTS

ON

GEOMAGNETIC VARIATIONS

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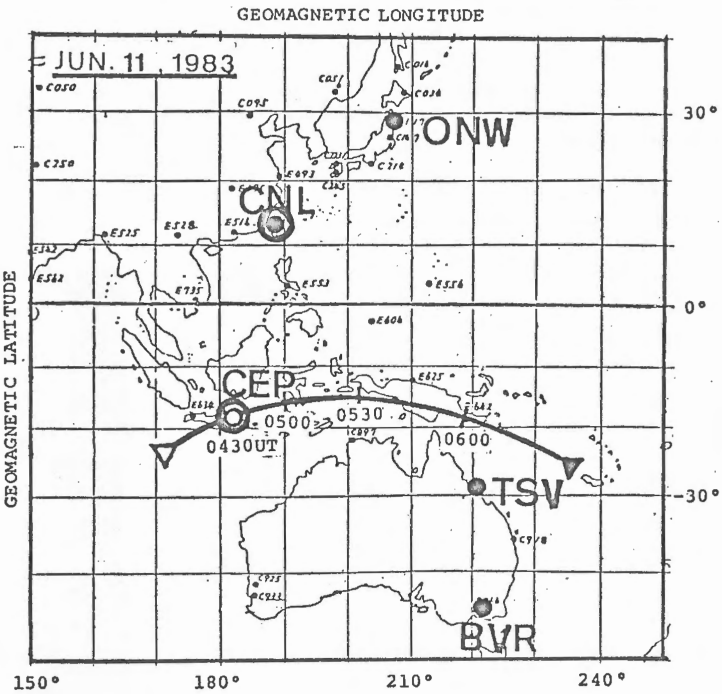
(1) Introduction

The purpose of this report is to describe a successful observation for the study of solar eclipse effects by new type magnetometers at a pair of conjugate stations. The observation was carried out at the two stations: Cepu (Indonesia) and its conjugate station, Chung-Li (Taiwan). The Cepu team (Saito, Yumoto, and Kitamura) was kindly supported by LAPAN, and the Chung-Li team (Tamura and Seto) by National Central University. The project was cooperated with simultaneous observation at the three sub-stations: Onagawa (Japan), Townsville (Northern Australia), and Beveridge (Southern Australia) as shown in Fig. 1-1.

All the observations were carried out with the same type of rulfmeters as will be described in (2). The outline of the observation will be described in (3), while the representative magnetograms will be displayed in (4). The clear eclipse effects are revealed as will be described in (5).

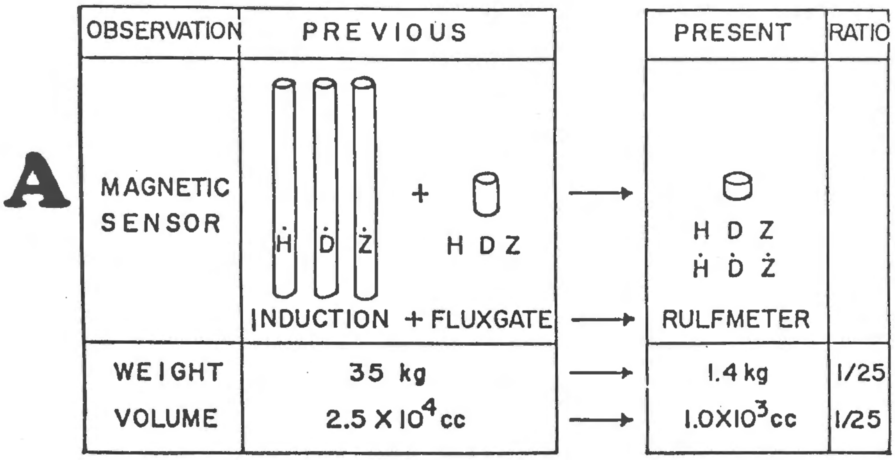
STATION	GEOGRAPHIC		GEOMAGNETIC		L
	LAT.	LONG.	LAT.	LONG.	
ONAGAWA	38.43N	141.48E	28.55	208.14	1.30
CONJUGATE P.	20.97S	139.30E	-28.55	208.14	1.30
CHUNG-LI	25.00N	121.17E	13.8	189.5	1.06
CEPU	7.13S	111.59E	-18.32	182.46	1.11
TOWNSVILLE	19.27S	146.78E	-28.10	220.63	1.29
BEVERIDGE	37.77S	145.08E	-46.61	222.28	2.12

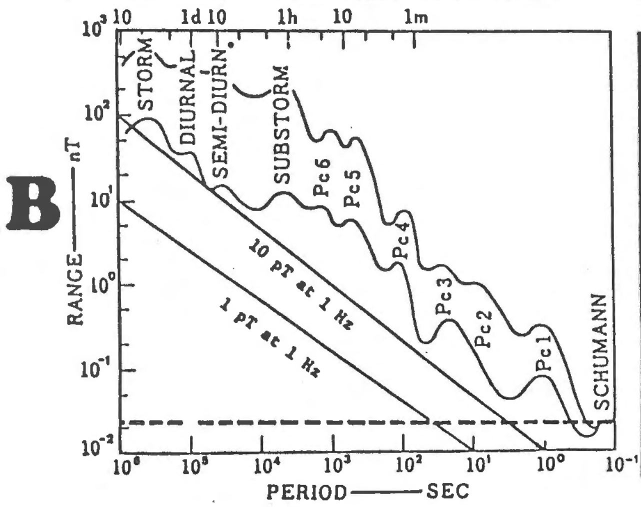


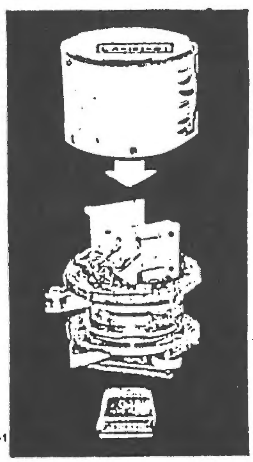
(2) New ring-core ULF magnetometer

Our geomagnetic observation is characterized by the use of a new type magnetometer, i.e., Ring-core ULF magnetoMETER, that is called RULFMETER. Because of the high sensitivity of ring-core sensor, only one small triaxial ring-core sensor can provide all the six components, H, D, Z, $\dot{H}$, $\dot{D}$, and $\dot{Z}$ by taking output of ordinary H, D, Z as fluxgate, and the other set of output, $\dot{H}$, $\dot{D}$, and $\dot{Z}$, through appropriate filters (Saito et al., 1981). Both the size and the weight of our rulfmeter is only 1/25 of the traditional induction and fluxgate in the sensor part as shown in Figure A. The small size and weight mean not only a handy type for field observation, but also saving of all the packages, carriages, man power, supplies, etc. These are immeasurably great merits especially in carrying out oversea geomagnetic observation. Figure B shows the noise level of the rulfmeter, which is much smaller than actual magnetic variations in the 1Hz-DC frequency range.

RULFMETER(⇐ RING-CORE ULF MAGNETOMETER)

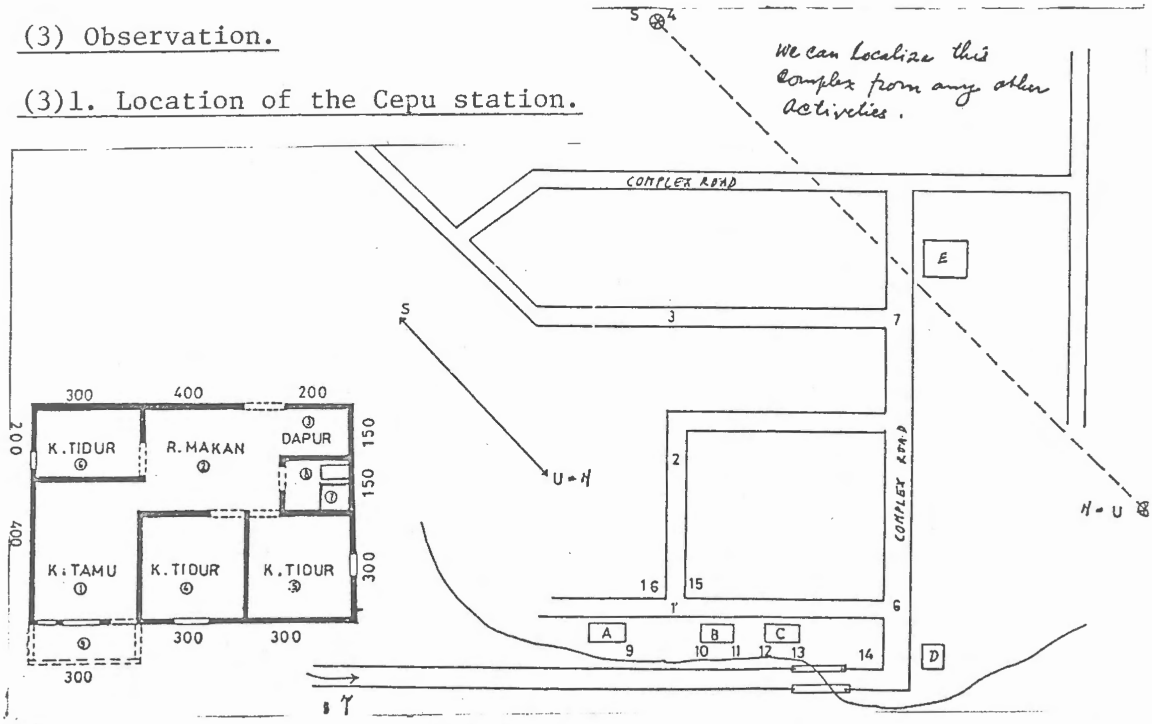


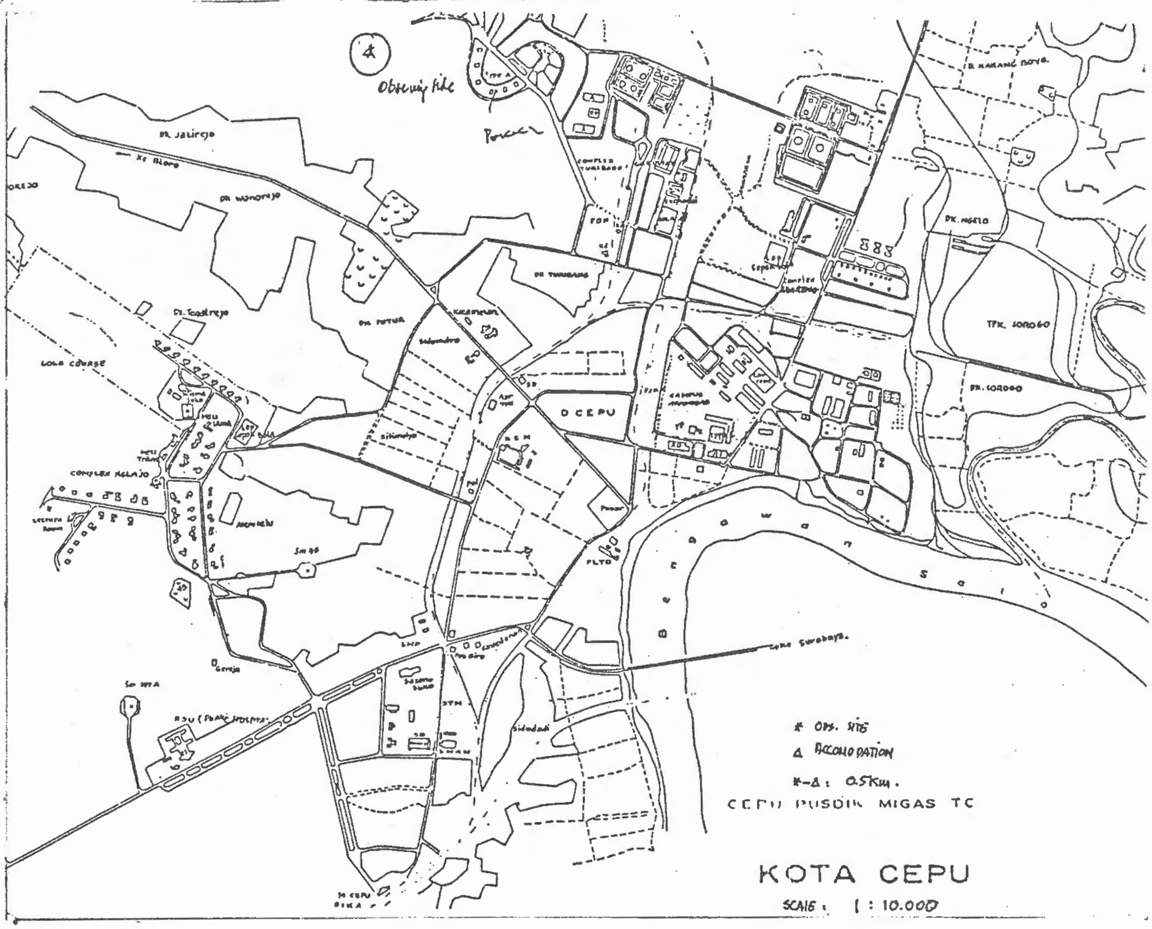




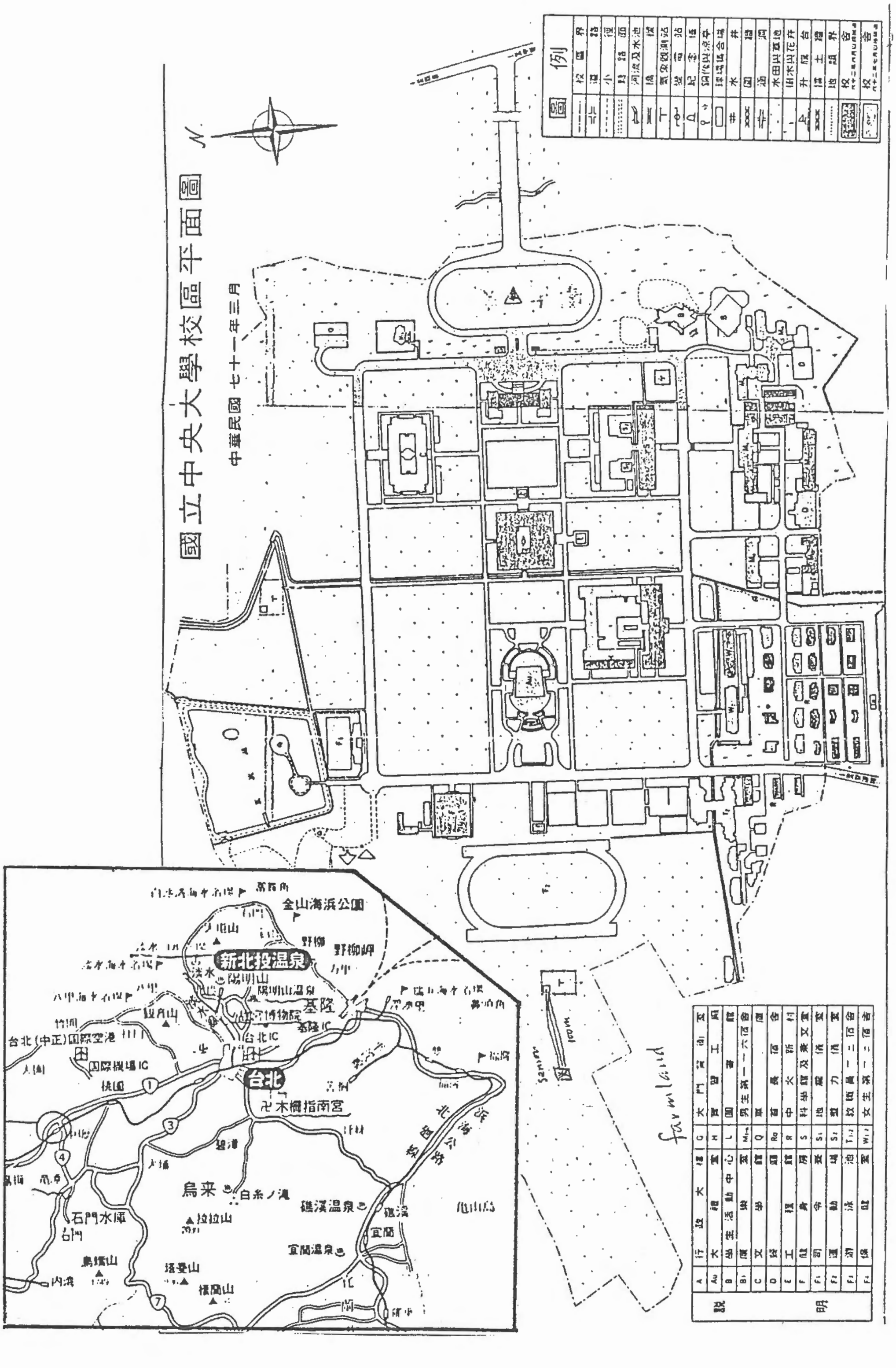
(3) Observation.

(3)1. Location of the Cepu station.

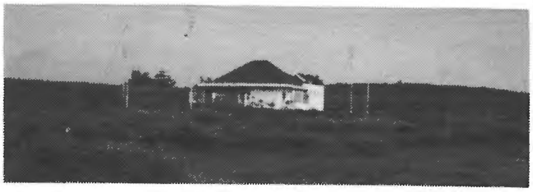


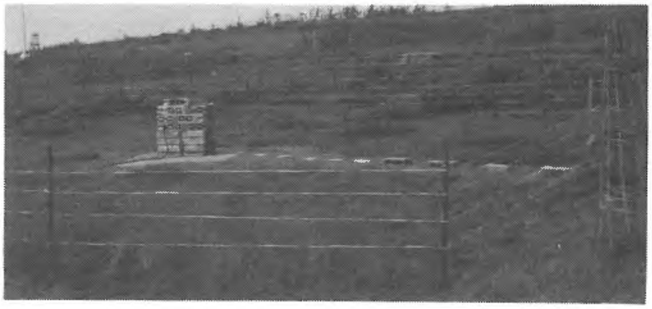


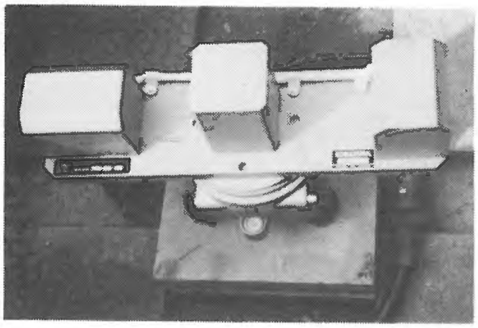
(3)2. Location of the Chung-Li stations.

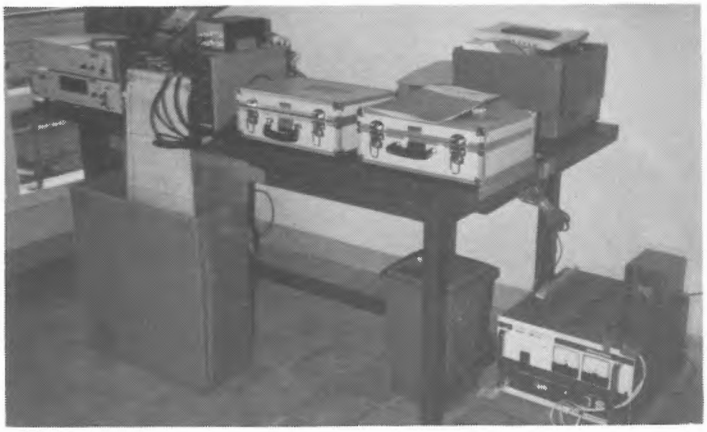


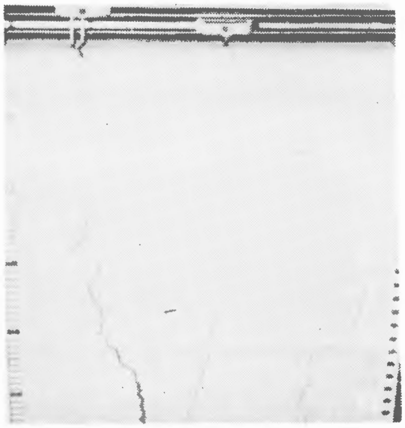
(3)3. Pictures of the Cepu station.



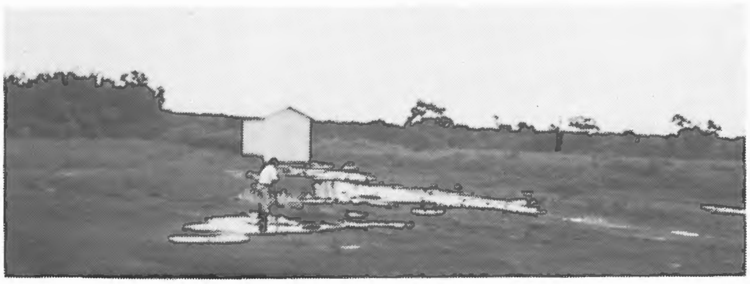


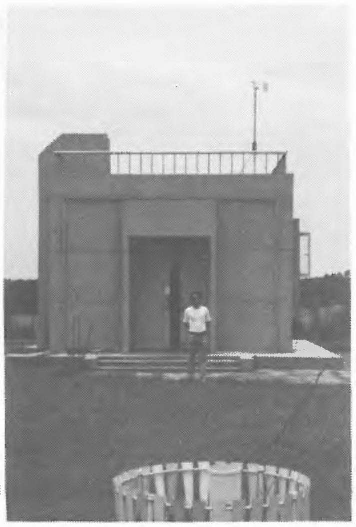




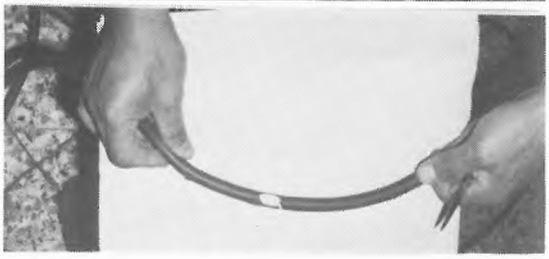
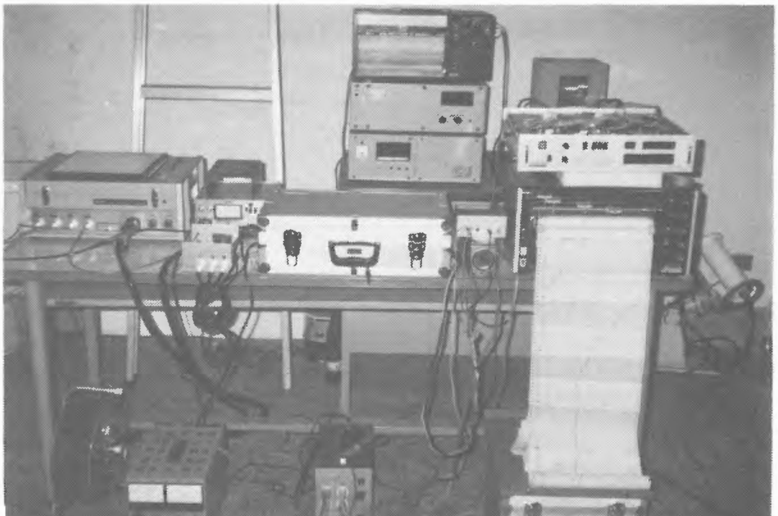


(3)4. Pictures of the Chung-Li station.







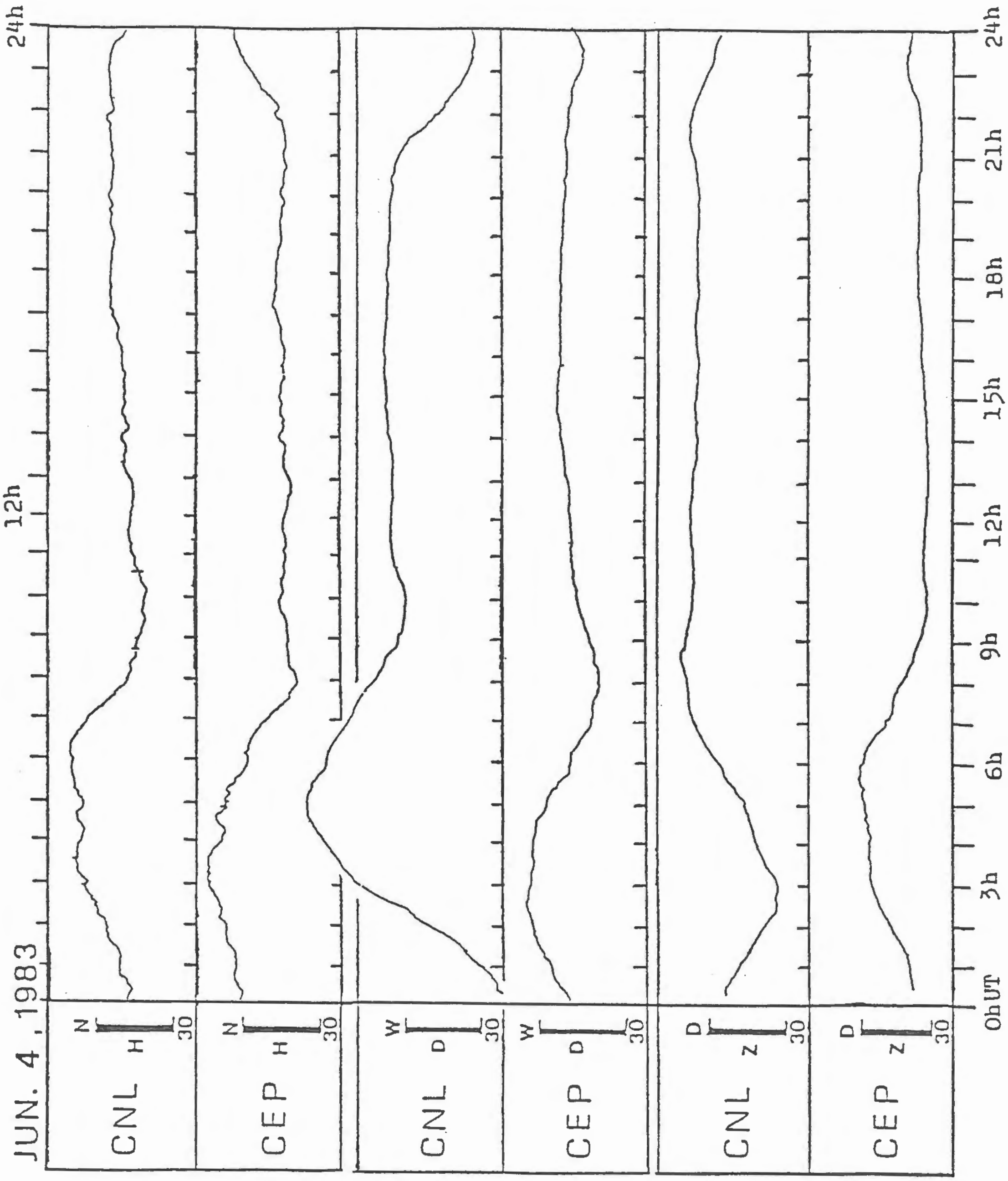

(3) 5. Time schedule of the Cepu team

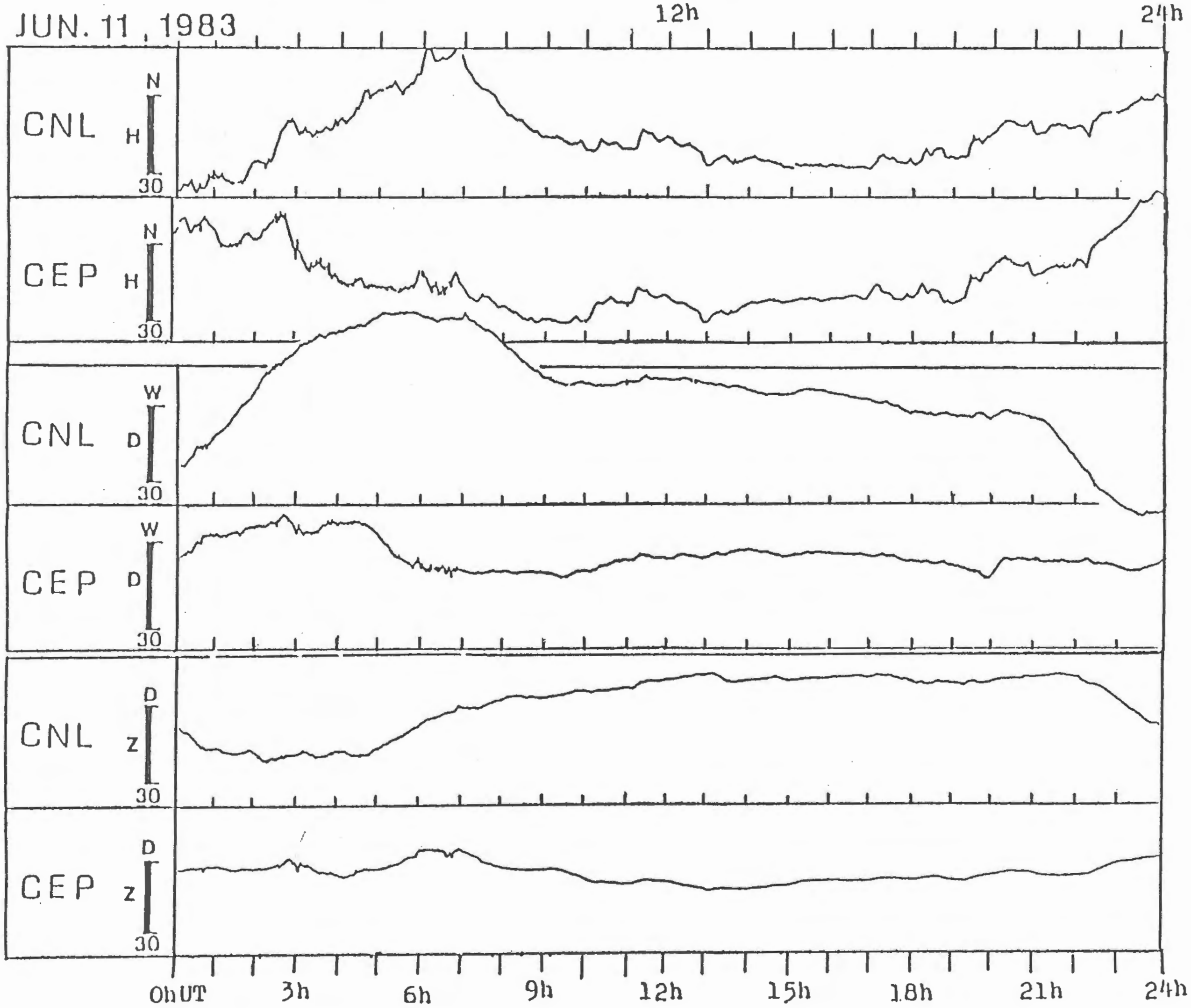
Name	Date	City	Remarks
	1983		
T. Saito K. Yumoto Y. Kitamura	May 21 (Sat)	Lv. Tokyo (NRT) Ar. Jakarta	GA-873 (11:00 → 16:30) LIPI, LAPAN, etc.
	May 22 (Tue)	Lv. Jakarta Ar. Surabaya	Meeting at ARC
	May 23 (Wed)	Lv. Surabaya Ar. Watucosek	by Car Receive cargoes of Geomag. Team
	May 26 (Thu)	Lv. Watucosek Ar. Cepu	Transported by truck
	May 27 (Fri) ~ May 28 (Sat)		Setting of Magnetometer
	May 29 (Sun) ~ Jun.14 (Tue)		Recording (→June 14, 09:00) Packing
K. Yumoto Y. Kitamura	Jun.15 (Wed)	Lv. Cepu Ar. Surabaya	by Car Assemble cargoes Geomag./ Balloon Teams transported by truck to Surabaya
	Jun.16 (Thu)	Lv. Surabaya Ar. Jakarta	
	Jun.16 (Thu) Jun.17 (Fri)	Lv. Jakarta Ar. Tokyo (NRT)	GA-888 (19:30 → via Denpasar → 07:00)
T. Saito	Jun.16 (Fri) ~	Lv. Cepu Ar. Bandung	Thanks to LAPAN Customer
	Jun.19 (Sun)	Lv. Bandung Ar. Jakarta	
	Jun.19 (Sun) Jun.20 (Mon)	Lv. Jakarta Ar. Tokyo (NRT)	GA-872 (22:00 → 07:00)

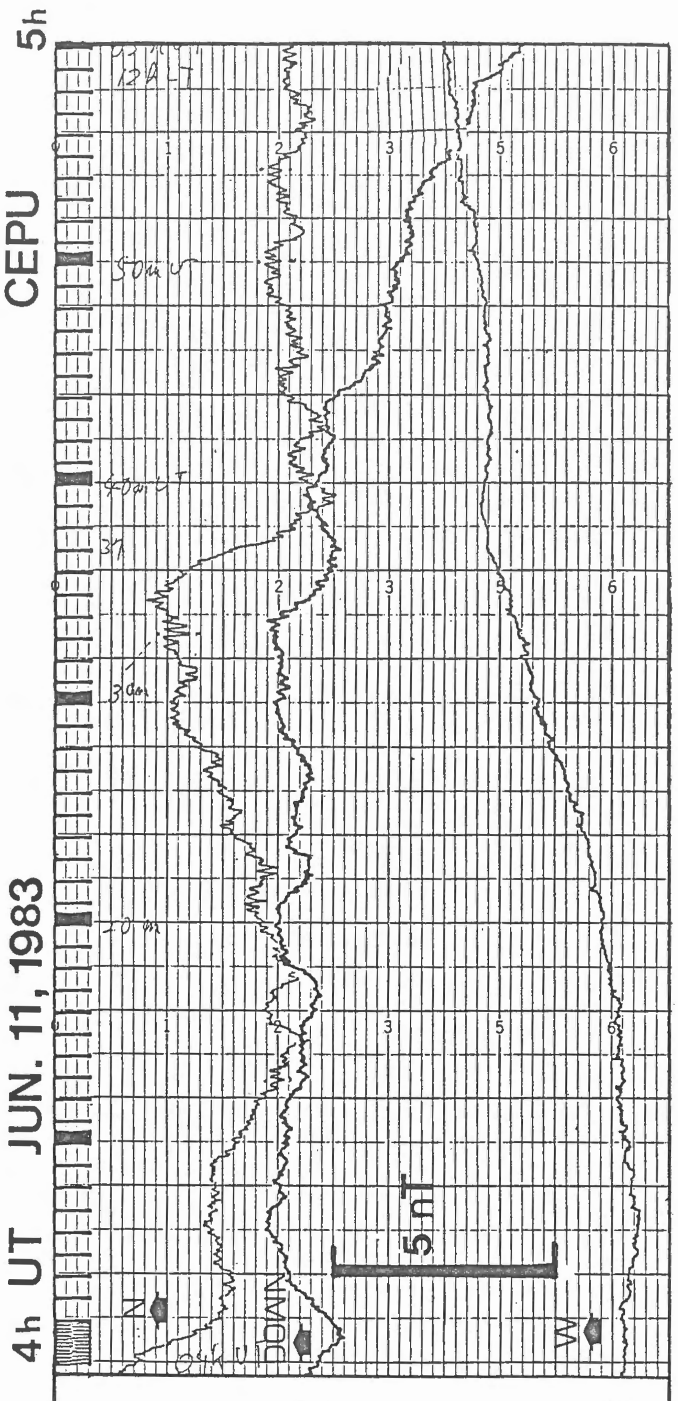
(3) 6. Time schedule of the Chung-Li team

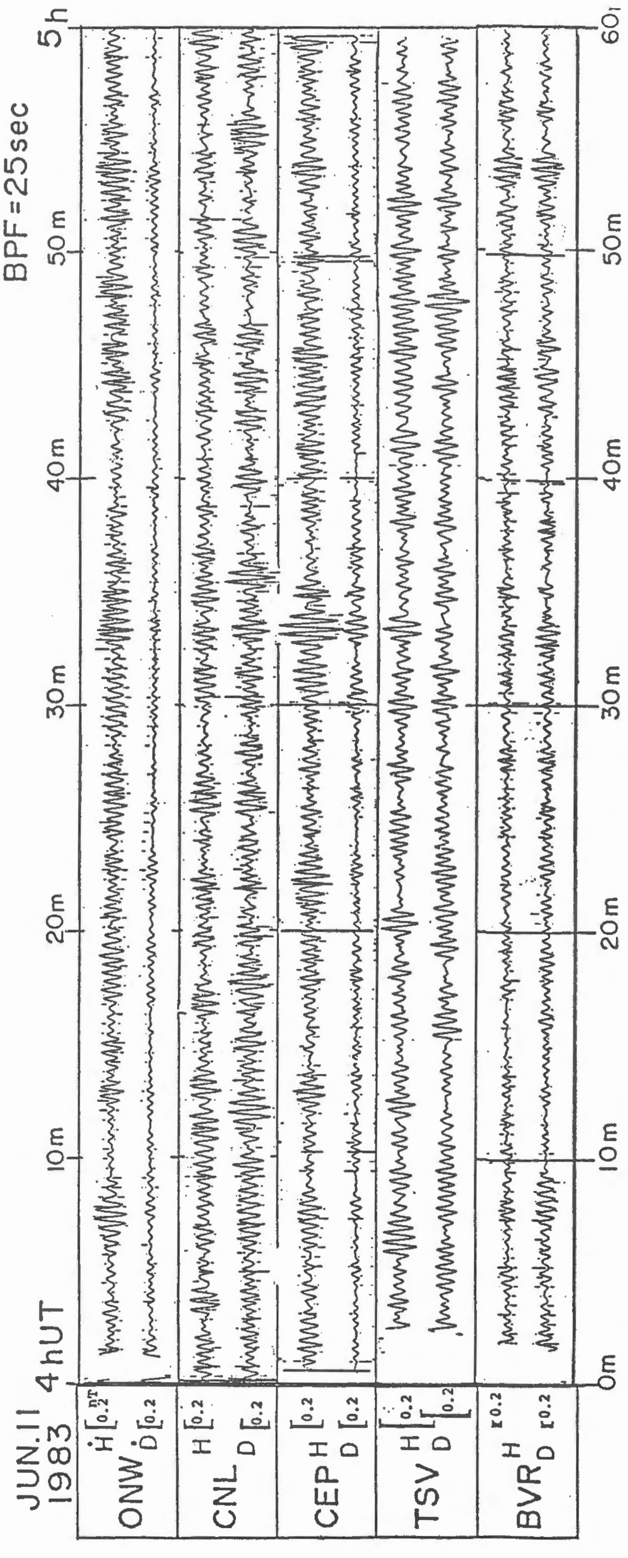
Name	Date	City	Remarks
	1983		
M. Seto	May 27 (Fri)	Lv. Tokyo Ar. Taipei	SQ-007 (09:30 → 11:50)
		Lv. Taipei Ar. Chung-Li	by Car
T. Tamura	May 28 (Sat) ~ May 29 (Sun)		Receive cargoes of Geomag. Team Setting of Magnetometers
	May 30 (Mon) ~		Recording (→June 14, 0900UT)
T. Tamura	Jun. 7 (Tue)	Lv. Taipei Ar. Tokyo	SQ-008 (16:20 → 20:20)
M. Seto	Jun.14 (Tue)		Packing
	Jun.15 (Wed)	Lv. Chung-Li Ar. Taipei	Transport cargoes by truck to Taipei
	Jun.16 (Thu)	Lv. Taipei Ar. Tokyo	SQ-008 (16:20 → 20:20)

(4)1. Representative Rulfgrams.

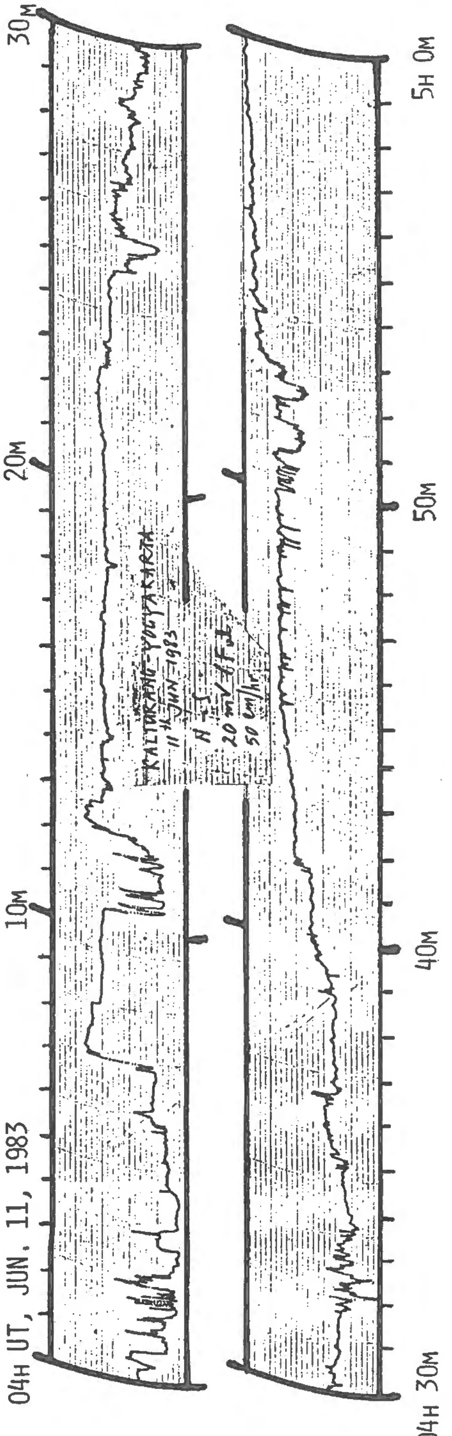


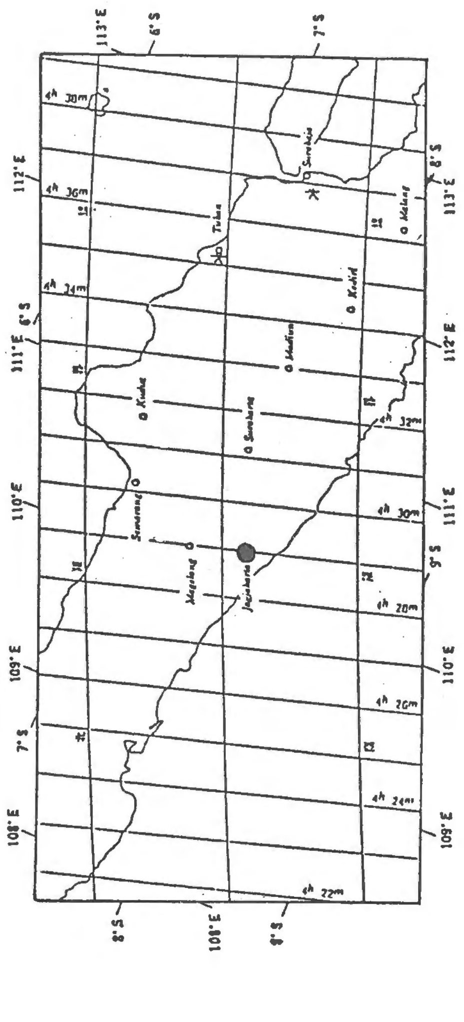

JUN. 11, 1983
12h
24h
CNL H
N
30
CEP H
N
30
CNL D
W
30
CEP D
W
30
CNL Z
D
30
CEP Z
D
30
0hUT
3h
6h
9h
12h
15h
18h
21h
24h


4h UT JUN. 11, 1983
CEPU
5h
H
Z
D
5nT
N
DOWN
W


JUN.11 1983
4hUT
5h
BPF=25sec
ONW H D
CNL H D
CEP H D
TSV H D
BVR H D
0.2
0m
10m
20m
30m
40m
50m
60m

(4)2. Representative Tellurigram (obtained by LAPAN).

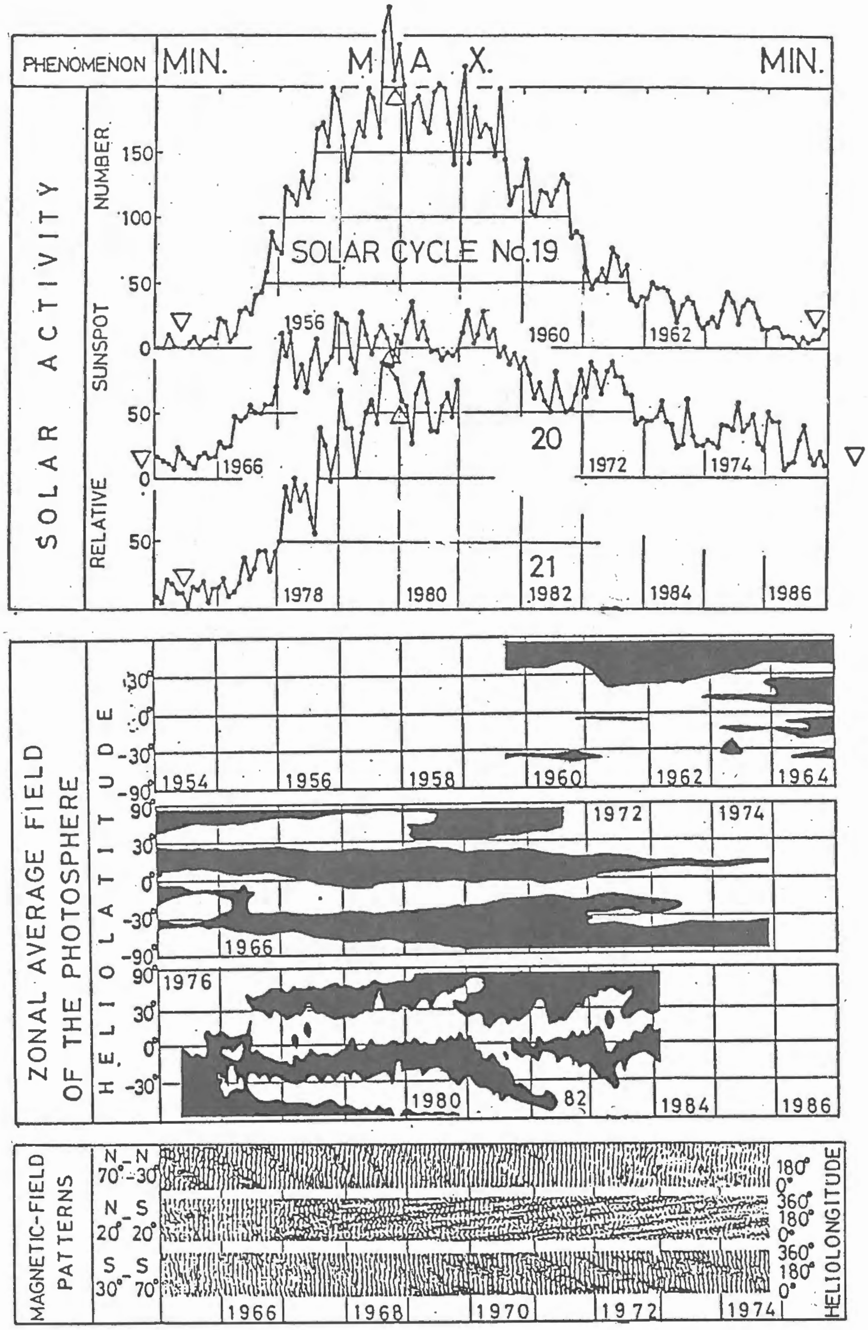




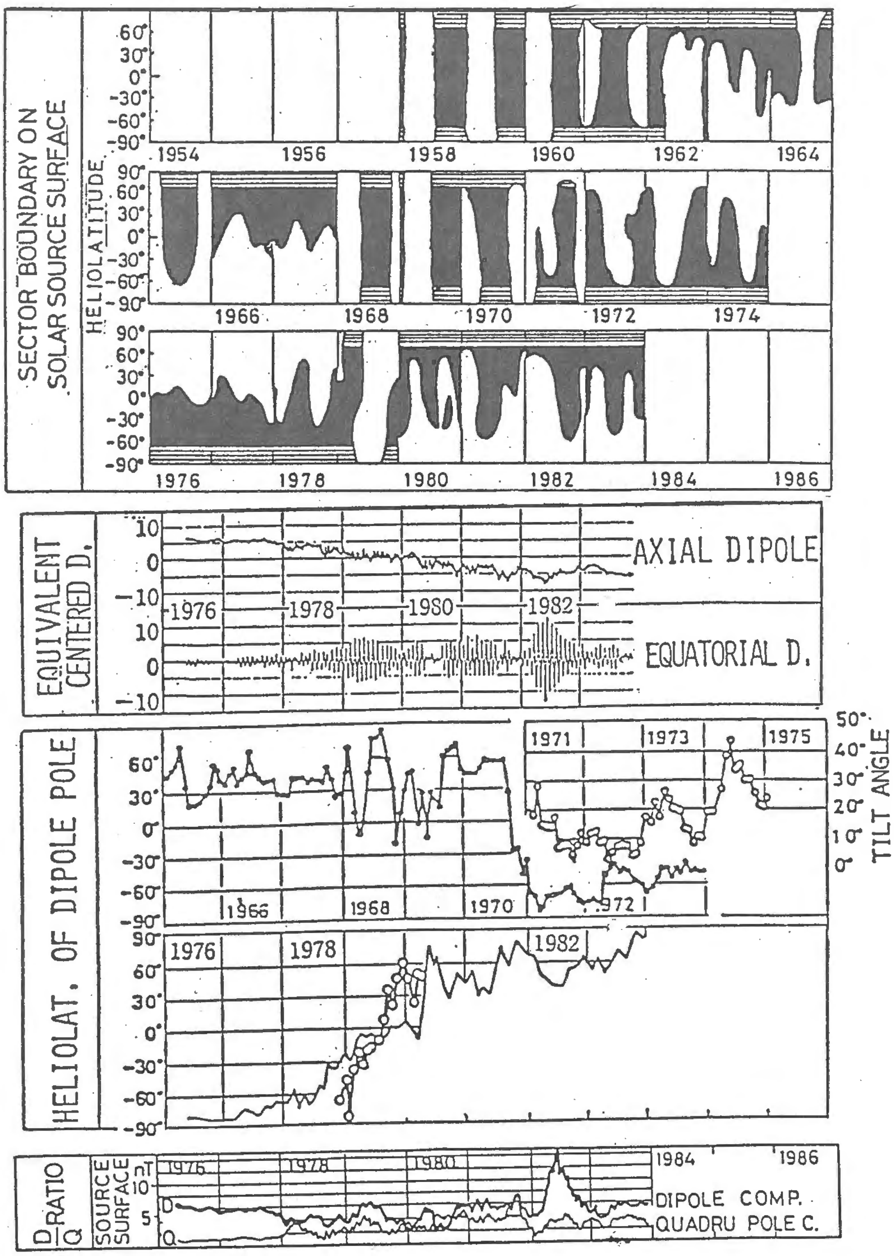
(5)1. Solar corona as a source of geomagnetic activity.

A physical relation between the coronal configuration on the eclipse day and the geomagnetic activity during the expedition is clarified.

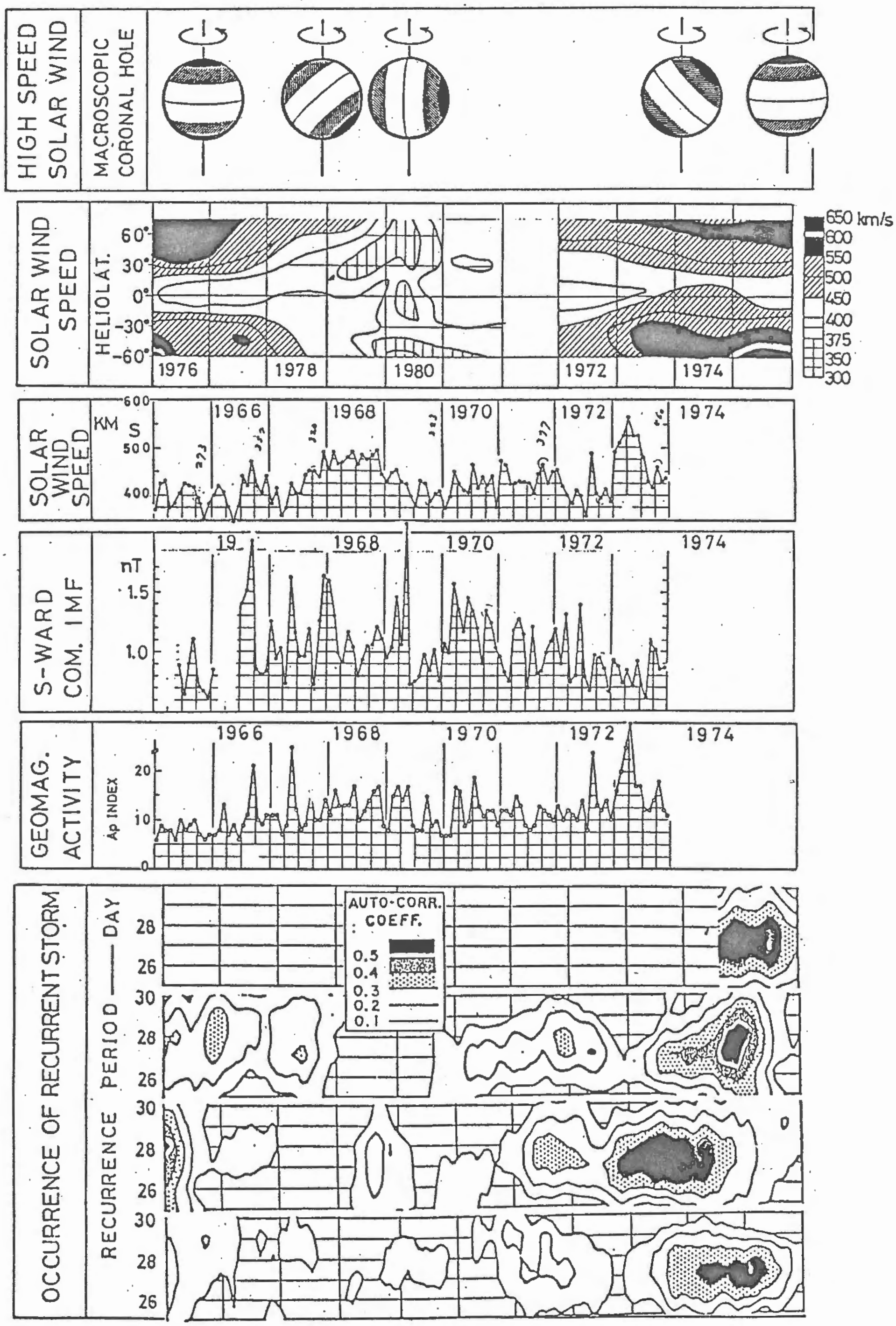
(A) Expected magnetic condition on the photosphere in 1983.



(B) Expected magnetic condition on the solar source surface in 1983.

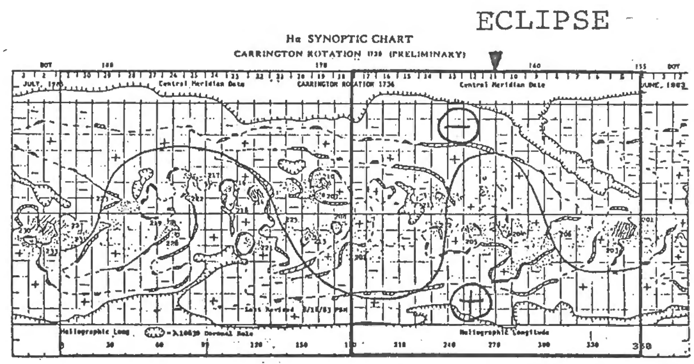


(C) Expected interplanetary and geomagnetic condition in 1983.



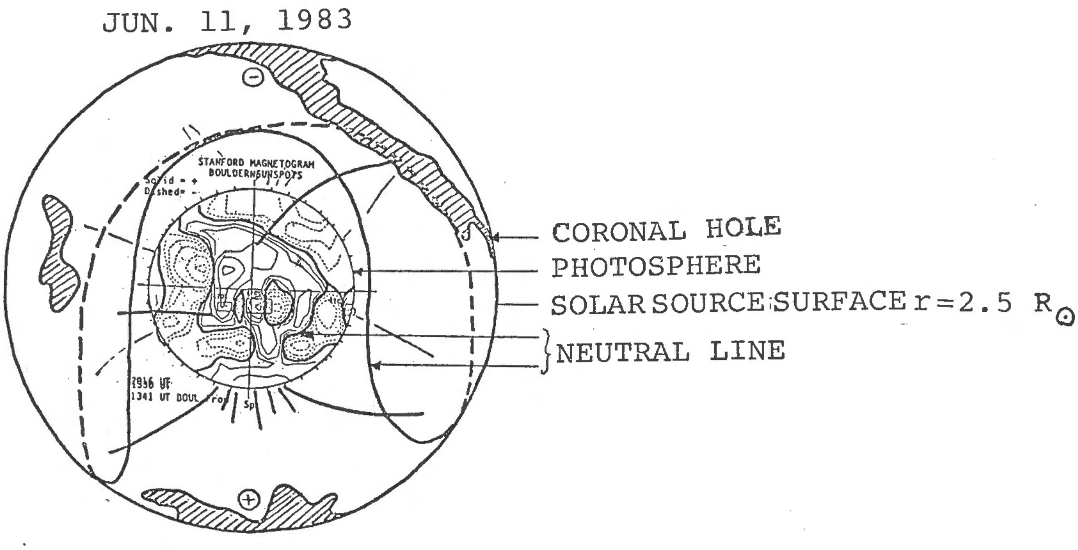
(D) Magnetic neutral line and solar phenomena.

The relations among them near the eclipse day are explained in terms of the heliomagnetosphere derived from (A) and (B).



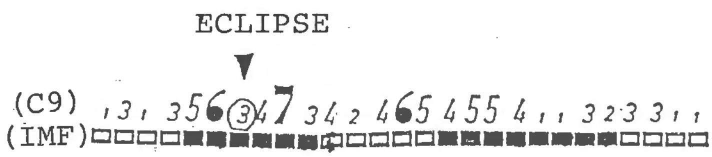
(E) Magnetic polarity of the coronal streamers.

The polarity is explained by the neutral lines on the photosphere and the source surface.



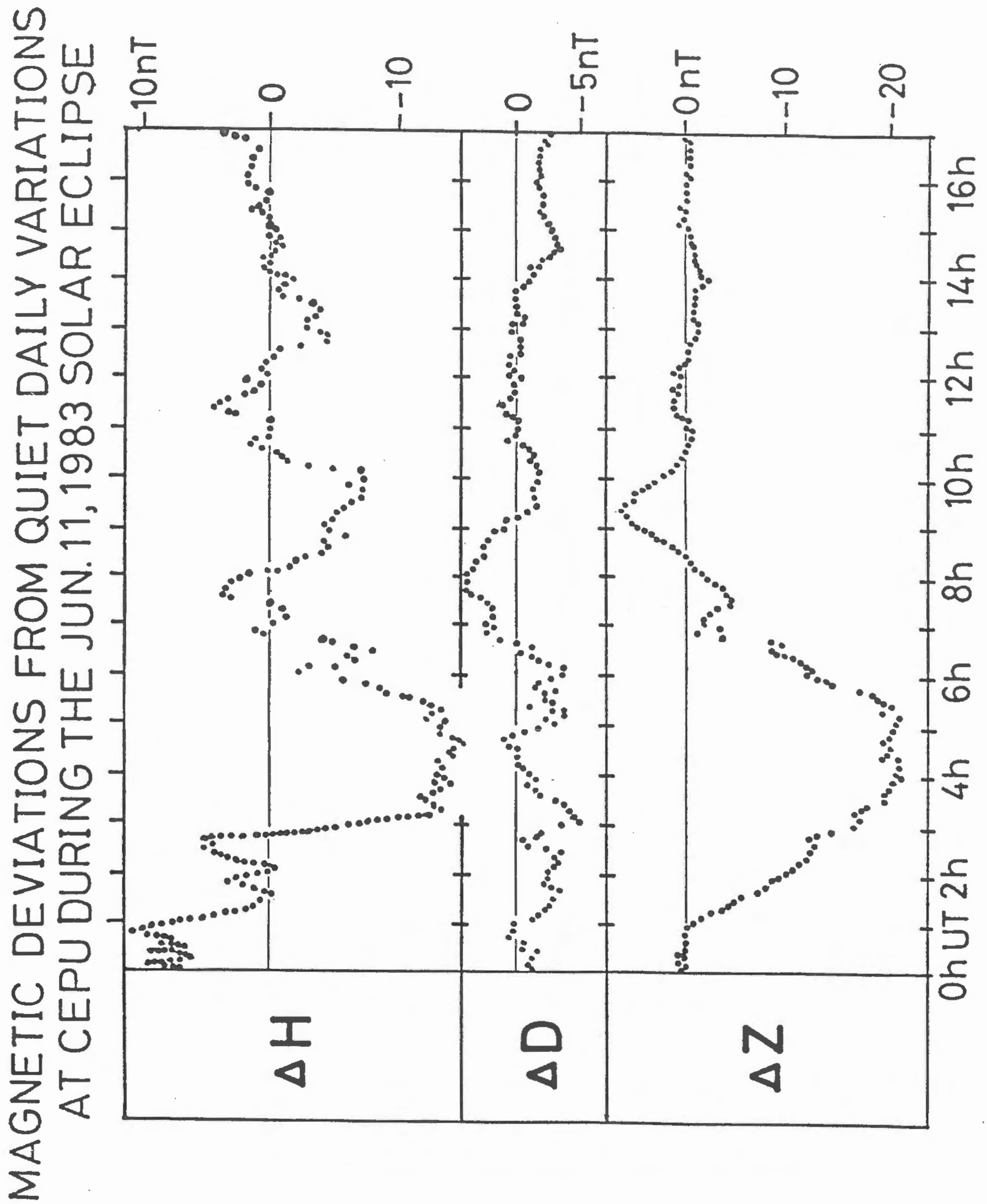
(F) Interplanetary and geomagnetic condition.

The condition during the expedition is well clarified by the relation in (E).

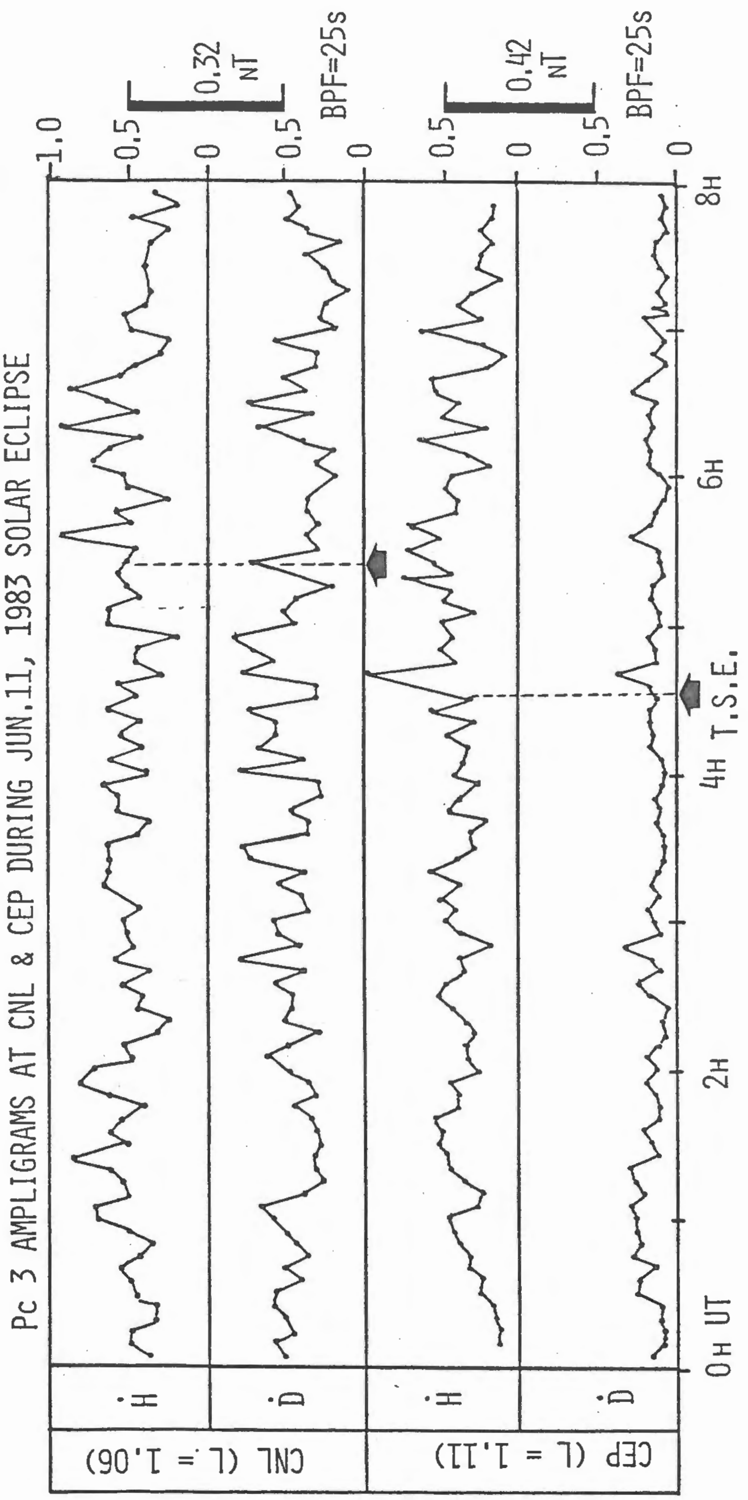


(5)2. Solar eclipse effects.

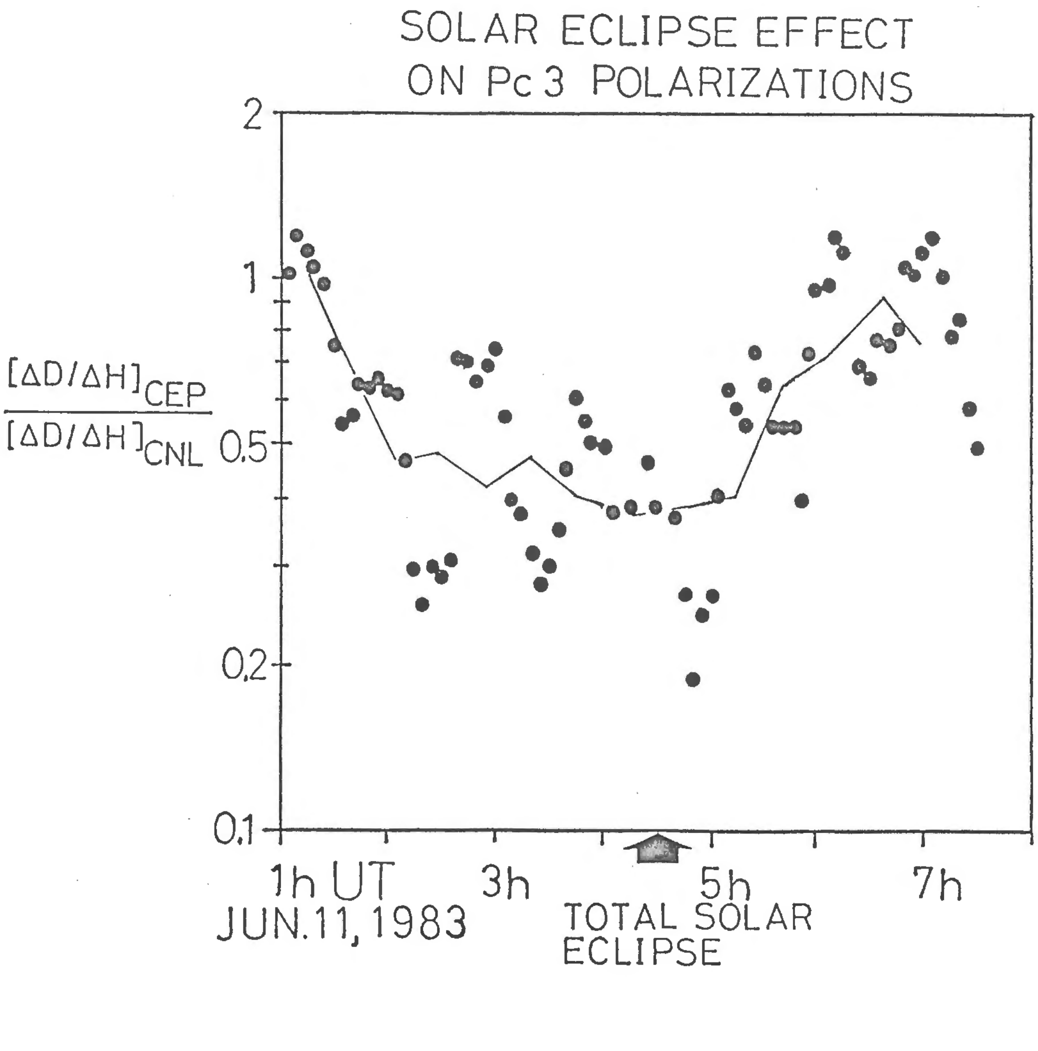
(A) Eclipse effect on S_q variation is clearly revealed.



(B) Geomagnetic Pc 3 pulsations at the conjugate stations.



(C) Eclipse effect on Pc 3 polarizations is clearly revealed.



(6) Acknowledgement

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They are greatly indebted to Prof. K.D. Cole and Dr. P. Dyson of La Trobe University, Prof. J. Ward and Dr. B. Gibson-Wilde of James Cook University, and Prof. H. Oya and Mr. M. Kondo of Tohoku University for their cooperative observation of geomagnetic variations at Beveridge, Townsville, and Onagawa, respectively.

The expeditions were carried out with warm supports by administrative offices of both Tohoku University and Faculty of Science, to whom the members wish to express their sincere gratitudes.

(7) References

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