fundamental and the second harmonic of type III and II bursts. We would like to hear the difference.

Wild, J. P.: Recent work by Smerd, Sheridan and me (presented at the I. A. U. meeting at Berkeley) has shown that in 4 out of 4 cases the second harmonic of a type II burst arrives from a position considerably *closer* to the solar flare than the fundamental observed (minutes before) at the same frequency. The simple application of the plasma hypothesis would suggest just the opposite. However, if it is supposed that the outward moving stream excites harmonic radiation dominantly in the *inward* direction, then the result can be explained using the conventional ray trajectories of the reflected ray. We have formed that such inward propagation appears to be consistent with the theory of Ginzburg and Zherezniakov that the harmonic radiation originates from combination scattering of a Cerenkov plasma wave in the thermal corona.

Corresponding measurements for type III bursts are inconclusive.

Morimoto, M.: We have many examples of a very much extended source of type II burst at 200 Mc/s. Is there any phase inversion in the fringe of the wider separation antenna system?

Wild: The phase of the pattern recorded with the wide space interferometer relative to the narrow space can vary considerably, especially in the case of type II bursts for which complete phase reversal can sometimes occur. The assumption of symmetry therefore involves a very coarse approximation with these bursts.

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II-3A-9. A Model of the Coronal Condensation

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The electron density and the electron temperature of the coronal condensation were determined by the optical observation at the total solar eclipse of October 12, 1958 in the South Pacific. The distribution of the electron density was derived from the direct photographs of the corona. At 100,000 km above the photosphere the electron density was ten times higher in the condensation than in the normal corona. The temperature is uncertain owing to the ambiguity in collisional cross-section. From the equivalent widths of three emission lines, *i.e.*, $\lambda\lambda$ 3987 Fe XI, 4086 Ca XIII and 4231 Ni XII appearing on our flash spectrograms, the electron temperature was estimated to be slightly higher in the condensation than in the normal corona.

§1. Introduction

Many studies on the coronal condensation have so far been made by radio techniques[1]. From optical observations we have as yet little information as to the model of the condensation because of the difficulty of observation. The intensity of the coronal condensation is optically faint and severely affected by the strong intensity of the photosphere. With a coronagraph we may be able to observe emission lines[2)-4)] of the condensation. The results are mainly used to deduce the temperature. However, the intensity of the continuum[2),3)] of the condensation, which will give the electron density, is difficult to observe. With a *K*-coronameter we could observe polarization of K corona and determine the electron density[5], but there remains difficulties in removing the instrumental and atmospheric effects.

This paper reports preliminary studies on the electron density and temperature in the coronal condensation by the optical observations at the total solar eclipse of October 12, 1958 in the South Pacific[6]. On our spectrograms, the intensity of the coronal continuum along the limb at the second contact side was not constant and stronger in a region, where the line of higher ionization potential such as 4086 Ca XIII was stronger than those of lower one, such as $\lambda\lambda$ 3987 Fe XI and 4231 Ni XII.

It was confirmed by direct photographs of the corona taken at the same eclipse and also by the radio observation in Sydney, that the intensity increases in the continuum and the emission lines were due to the coronal condensation.

The distribution of electron density was derived from the isophote of the direct photograph of the coronal condensation, assuming the model of van de Hulst (max. eq.)[7] for the surrounding corona and the shape of the condensation to be cylindrical. The electron density in the condensation at 100,000 km was about ten times higher than that in the normal corona. The temperature in the condensation was inferred from equivalent widths of three emission lines, $\lambda\lambda$ 3987, 4086 and 4231, in the condensation and in the normal corona. At the place, higher than 80,000 km, the temperature in the condensation turned out to be higher by a few hundred thousand degrees than that of the surrounding corona.

§ 2. Data

The spectrograph, fed by 30 cm coelostat, was about the same as the conventional slitless spectrograph and composed of a 203×128 mm Baush and Lomb replica grating with 1200 grooves/mm and two camera lenses, one being a 20 cm doublet of 300 cm in focal length for the first order violet and the other, a 15 cm triplet of 340 cm in focal length for the first order red, which covered two spectral ranges from 3600 A to 4400 A and from 5800 A to 6600 A. Dispersions were 2.3 A/mm in the both spectral ranges. Direct photographs of the corona were taken with a 5.7 cm doublet of 225 cm in focal length.*

A map of sunspots on the eclipse day is shown in Fig. 1. The arrow C indicates a large sunspot group, relevant to the condensation, which appeared at the east limb about two days before the eclipse. The upper

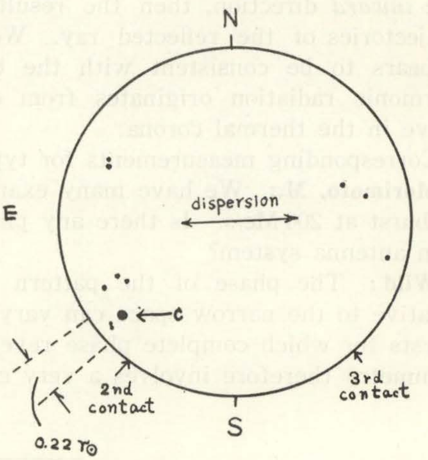

Fig. 1. Map of the sunspots on the eclipse day.

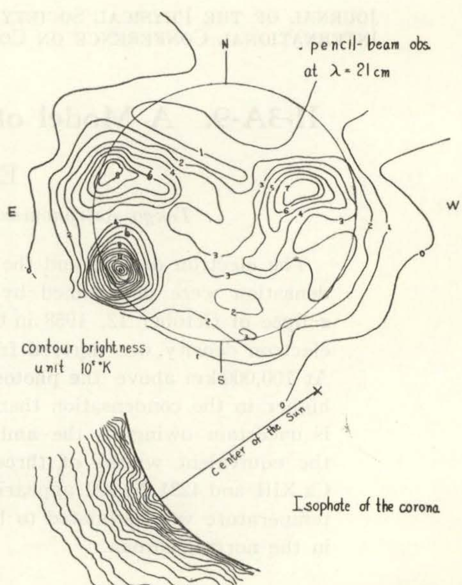

Fig. 2. Upper: The contours of the brightness temperature in unit of 10^5°K.
Lower: A part of the isophote of the corona.

* They were taken by N. Owaki, Hydrographic Office of Japan, to whom the author is indebted for the use of a picture.

diagram* of Fig. 2 illustrates the contour of the brightness temperature by the pencil-beam observation at $\lambda=21$ cm in Sydney, which shows the large condensation having the temperature of $1.7\cdot10^6$°K near the east limb. The isophote of a direct photograph of this condensation is also reproduced in Fig. 2.

The measured emission lines of the condensation were $\lambda\lambda$ 3987 Fe XI, 4086 Ca XIII and 4231 Ni XII, and the equivalent widths of these lines are shown in Table I.

Table I.

Identification			Equivalent Width (A)		W_c / W_n
λ	Ion	Ion. Pot. (eV)	Normal	Condensation	
3987	FeXI	261	0.07	0.11	1.5
4231	NiXII	318	0.10	0.22	2.3
4086	CaXIII	655	0.11	0.41	3.6

Equivalent width in the normal corona and the coronal condensation. At the condensation the line of higher ionization potential, λ 4086, shows larger increase in equivalent width than the other lines of lower ionization potential. This fact suggests that the condensation may be higher in temperature.

§ 3. Electron Density

Let us assume the coronal condensation to be surrounded by the normal corona and to be located above the sunspot, marked with C, as shown in Fig. 1. Then we could not observe the lower region of the condensation, but observe somewhat higher region, *i.e.*, higher than 80,000 km above the limb.

The distribution of electron density may be derived from the isophote of the direct photograph as shown in Fig. 3. It may be remarked here that every point on the same contour of the isophote gives the same observed intensity, which is resulted from integrating the scattering of sunlight by electron from $-\infty$ to $+\infty$ along the line of sight and the deviation from the circular symmetry as shown in Fig. 2 might mean more electrons to be in the condensation than in the normal corona.

We assume that the surrouding corona was normal one of van de Hulst's model (max. eq.) and the shape of the condensation was cylindrical. Then the difference between the intensity of the condensation at a height and that of the normal corona at the same height should be contributed by the condensation. Assuming the length of the condensation in the line of sight to be $0.22\,R_\odot$, we obtained the electron density in the condensation at each height (Fig. 3). At 100,000 km above the photosphere, the electron density in the condensation was ten times higher than that in the normal corona.

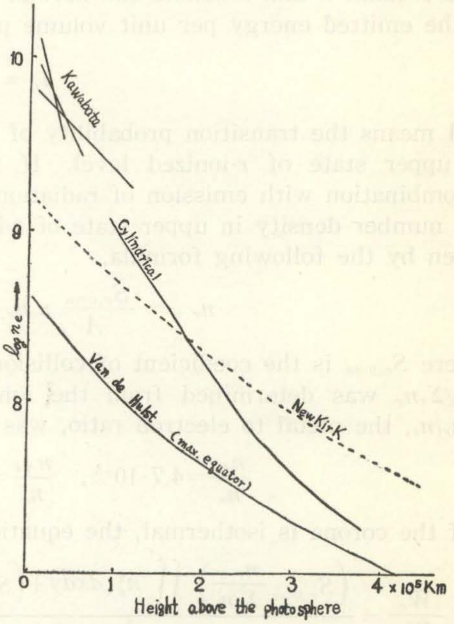

Fig. 3. The distribution of the electron density

From the statistical investigation of the slowly-varying component K. Kawabata[8] has found the electron density in the condensation at the lower part, which we could not observe at the eclipse. It seems that K. Kawabata's value and the extrapolated one of our distribution are in good agreement.

It is noted here that the scale height of the condensation was found smaller than that of the normal corona and the temperature estimated from the density gradient of the condensation was $9\cdot10^5$°K, which is smaller than that of the normal corona, *i.e.*, $1.6\cdot10^6$ °K. However the temperature of the condensation, estimated from the equivalent width, was seen to be higher than that in the normal corona. If the normal corona is

* The author wishes to express his thanks to Dr. W. N. Christiansen for the map used for this work.

in hydrostatic equilibrium, we might have to consider some compressing factor, (a magnetic field for example) for the equilibrium of condensation.

§ 4. Temperature

The temperature in the condensation was uncertain owing to the ambiguity in collisional cross-section[9], so we have determined only the relative temperature in the condensation, using the ratios of equivalent widths in the condensation and in the normal corona for each emission line.

The ratio of equivalent width is given by the following formula,

$$\frac{W_c}{W_n}=\frac{\iint_c \varepsilon_{L,c}dxdy+\int_{-\infty}^{+\infty}\int_h^{\infty}\varepsilon_{L,n}dxdy-\iint_c \varepsilon_{L,n}dxdy}{\int_{-\infty}^{+\infty}\int_h^{\infty}\varepsilon_{L,n}dxdy}\,, \tag{1}$$

where suffix n and c denote the normal corona and the condensation, respectively, and ε_L is the emitted energy per unit volume per unit solid angle and is given as follows,

$$\varepsilon_L=\frac{h\nu}{4\pi}An_{r,u}\,. \tag{2}$$

A means the transition probability of spontaneous emission and $n_{r,u}$ the number density in upper state of r-ionized level. If we assume the electron-ionization, electron-capture recombination with emission of radiation and collisional excitation for three emission lines, the number density in upper state of r-ionized level $n_{r,u}$ of the relevant element can be given by the following formula,

$$n_{r,u}=\frac{S_{r,0\to u}}{A}n_e n_{r,0}=\frac{S_{r,0\to u}}{A}n_e\frac{n_{r,0}}{\Sigma_r n_r}\cdot\frac{\Sigma_r n_r}{n_e}\cdot n_e\,, \tag{3}$$

where $S_{r,0\to u}$ is the coefficient of collisional excitation and is a function of temperature. $n_{r,0}/\Sigma_r n_r$ was determined from the ionization formula and is a function of temperature; $\Sigma_r n_r/n_e$, the metal to electron ratio, was taken from the paper by Woolley and Allen[10], *i.e.*,

$$\frac{n_{Fe}}{n_e}=4.7\cdot10^{-5}\,,\quad \frac{n_{Ni}}{n_e}=1.9\cdot10^{-6}\quad\text{and}\quad\frac{n_{Ca}}{n_e}=1.6\cdot10^{-6}\,.$$

If the corona is isothermal, the equation[1] can be written as follows,

$$\frac{W_c}{W_n}=\frac{\left(S_{r,0\to u}\frac{n_{r,0}}{\Sigma_r n_r}\right)_c\iint_c n_{e,c}^2dxdy+\left(S_{r,0\to u}\frac{n_{r,0}}{\Sigma_r n_r}\right)_n\left(\int_{-\infty}^{+\infty}\int_h^{\infty}n_{e,n}^2dxdy-\iint_c n_{e,n}^2dxdy\right)}{\left(S_{r,0\to u}\frac{n_{r,0}}{\Sigma_r n_r}\right)_n\int_{-\infty}^{+\infty}\int_h^{\infty}n_{e,n}^2dxdy}\,, \tag{4}$$

As the coefficient of collisional excitation is not so sensitive to the temperature, we safely neglected it. Moreover the value of $n_{e,n}$ and $n_{e,c}$ are adopted from Fig. 3.

Thus we have

$$\frac{W_c}{W_n}\cong\frac{\left(\frac{n_{r,0}}{\Sigma_r n_r}\right)_c\iint_c n_{e,c}^2dxdy}{\left(\frac{n_{r,0}}{\Sigma_r n_r}\right)_n\int_{-\infty}^{+\infty}\int_h^{\infty}n_{e,n}^2dxdy}+1=\frac{\left(\frac{n_{r,0}}{\Sigma_r n_r}\right)_c}{\left(\frac{n_{r,0}}{\Sigma_r n_r}\right)_n}\cdot2.6+1\,. \tag{5}$$

In this formula $n_{r,0}/\Sigma_r n_r$ was calculated as a function of temperature by using the ionization formula in Unsöld's textbook[11].

From the formula (5) and W_c/W_n in Table I the temperature in the condensation turned out to be $0.95\cdot10^6$°K for λ 3987 and $0.98\cdot10^6$ °K for λ 4231, if we take the temperature in the normal corona to be about $0.8\cdot10^6$°K. For λ 4086, however, the temperature in the condensation was about the same as that in the normal corona. Consequently the temperature in the condensation was at most by $0.2\cdot10^6$°K higher than that in the normal corona.

It may be noted here that we must take

much higher temperature than $0.8 \cdot 10^6$°K in order to be able to observe λ 4086. Therefore as I. S. Shklovsky[12] already pointed out, we might have to introduce an inhomogeneous corona with hot and cold elements both in the normal corona and in the condensation.

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Discussion

Biermann, L.: The problem of the several sources of information on the coronal temperature was rediscussed in a contribution to the I.A.U. corona symposium of last week by Lüst, Schmidt, Trefftz and myself. In so far the equivalent width gives eventually the temperature derived from the ionization equilibrium. This should lead to (relatively) the most trustworthy temperature value; but the whole subject is still to some extent controversial.

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II-3A-10. Structure of the Flare

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The line widths of Balmer series lines from H_α to H_{14} were measured on a number of spectrograms of disk flares and limb flares of medium importance taken by a wide range spectrograph with the dispersion of 3A/mm. From these widths we derived the values of the electron density and the total number of hydrogen atoms along the line of sight in the second quantum state. On the basis of uniform model of the flare, these two values can only be made compatible when the very small geometrical thickness of the order of 10 km is attributed to the whole extension of the disk flare and the limb flare. We like to suggest, therefore, that the flare is composed of unresolvably fine, presumably thread like, condensations distributed over the whole extension. Further since the limb flares show essentially the same structure as the disk flares, we are inclined to believe that the origin of the flare must lie somewhere in the corona or in the higher chromosphere. Moreover we suspect that all the disk flares might be limb flares seen projected on the disk.

Balmer series lines and metallic lines were measured on spectrograms taken with a wide range spectrograph which permits a simultaneous exposure of the wavelength range from $H\alpha$ to the Balmer continuum. Dispersion was about 3A/mm. Among one hundred spectrograms, 4 disk flares of importance 2^+ and 1^+, and two limb flares were selected for analysis[1),2)].

Profiles of disk flares were corrected for