ΠΡΑΚΤΙΚΑ ΤΗΣ ΑΚΑΔΗΜΙΑΣ ΑΘΗΝΩΝ

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ΑΣΤΡΟΝΟΜΙΑ.— **On the Difference Between the Intensity of the Chromospheric Background on the Polar and Equatorial Radii,** *by Constantin J. Macris**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ι. Ξανθάκη.

A B S T R A C T

The intensity of the $K_{2,3,2}$ chromospheric background is measured along the polar and equatorial solar radii and is found to be greater on the central meridian. The central meridian — equator intensity difference, at the same distance from the center of the solar disk, increases with the heliographic latitude. There are indications that the intensity of the chromospheric background decreases from the minimum of the solar cycle.

1. INTRODUCTION

In a previous paper (Macris, 1974) we found that the measurements of the ratio of the flocculi intensities to those of the background at the center of the solar disk and at distance $\sin\vartheta = 0.8$ on the polar and equatorial radii, are the following:

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* ΚΩΝΣΤ. Ι. ΜΑΚΡΗ, **Ἐπὶ τῆς διαφορᾶς τῆς ἐντάσεως τοῦ χρωμοσφαιρικοῦ βάθους ἐπὶ τῶν πολικῶν καὶ τῶν ἰσημερινῶν ἀκτίνων τοῦ ἡλιακοῦ δίσκου.** Research Center for Astronomy and Applied Mathematics, Academy of Athens.

$$I_{fl\,(c)} / I_{chr\,(c)} = 1.482 \quad (1)$$

$$I_{fl\,(Eq)\,0.8} / I_{chr\,(Eq)\,0.8} = 1.570 \quad (2)$$

$$I_{fl\,(NR)\,0.8} / I_{chr\,(NR)\,0.8} = 1.468 \quad (3)$$

$$I_{fl\,(SR)\,0.8} / I_{chr\,(SR)\,0.8} = 1.441 \quad (4)$$

We also found that the limb darkening on the equatorial radius at $\sin\vartheta = 0.8$ from the center is

$$I_{chr(Eq)\,0.8} / I_{chr(c)} = 0.650 \quad (5)$$

From the relations (2), (3) and (4) we conclude that

$$I_{fl(NR)\,0.8} / I_{chr\,(NR)\,0.8} < I_{fl\,(Eq)\,0.8} / I_{chr\,(Eq)\,0.8} \quad (6a)$$

$$I_{fl\,(SR)\,0.8} / I_{chr\,(SR)\,0.8} < I_{fl\,(Eq)\,0.8} / I_{chr\,(Eq)\,0.8} \quad (6b)$$

Thus, if we suppose that:

1) $I_{fl\,(NR,\,SR)\,0.8} = I_{fl\,(Eq)\,0.8}$, relations (6a) and (6b) imply that $I_{chr(NR,\,SR)\,0.8} > I_{chr\,(Eq)\,0.8}$ i.e. the intensity of the chromospheric background at the same distance from the center of the solar disk, on the polar radius regions is greater than that on the equatorial radius.

2) In the case $I_{fl\,(NR,\,SR)\,0.8} > I_{fl\,(Eq)\,0.8}$, the validity of (6a) and (6b) require $I_{chr(NR,\,SR)\,0.8} \gg I_{chr\,(Eq)\,0.8}$, i.e. the chromospheric background at $\sin\vartheta = 0.8$ on the polar radius must be much greater than that on the equatorial radius. This conclusion reinforces that one of case 2.

Thus the values of the ratios I_{fl} / I_{chr} at distance $\sin\vartheta = 0.8$ from the center of the solar disk on the equatorial and polar radii, lead to the conclusion that the chromospheric background is brighter near the polar regions than near the equatorial one.

The intensity of the chromospheric background at the polar regions is:

From (1) and (2) we have $(I_{fl\,(c)} / I_{fl\,(Eq)\,0.8}) \cdot (I_{chr\,(Eq)\,0.8} / I_{chr\,(c)}) = 1.482 / 1.570$ and using (5) we obtain

$$I_{fl\,(c)} / I_{fl\,(Eq)\,0.8} = 1.452 \quad (7)$$

If we consider the first case where $I_{fl(NR)\,0.8} = I_{fl\,(Eq)\,0.8}$, then we have.

a) For the north polar region from relations (1) and (3):

$$(I_{fl\,(c)} / I_{fl\,(NR)\,0.8}) \cdot (I_{chr\,(NR)\,0.8} / I_{chr\,(c)}) = 1.482/1.468$$

Since we assumed that the intensity of the flocculi is the same on the polar and equatorial radii at distance $\sin\vartheta = 0.8$ and according to relation (7) we have $I_{chr(NR)\,0.8} / I_{chr\,(c)} = 0.695$.

If we compare this with (5) we conclude that the ratio of the intensities of the chromospheric background at distance $\sin\vartheta = 0.8$ and at the center is by 0.045 greater than the ratio of the intensity on the equatorial radius at distance $\sin\vartheta = 0.8$ to that of the center of the disk.

b) For the south polar region from the relations (1), (4) and (7) that: $I_{chr(SR)\,0.8} / I_{chr(c)} = 0.708$. The comparison of this value with that of relation (5) gives a difference 0.058, which implies that the intensity of the chromospheric background of the south polar region at distance $\sin\vartheta = 0.8$ is greater than that of the equatorial region at the same distance, both compared to the central background intensity.

Therefore the differences $\Delta I_{(NR-Eq)}$ and $\Delta I_{(SR-Eq)}$ are respectively 0.045 and 0.058.

However if the second case is true : $I_{fl\,(NR,\,SR)\,0.8} > I_{fl\,(Eq)\,0.8}$, then the values of $I_{chr\,(NR,\,SR)\,0.8} / I_{chr\,(c)}$ must differ much more from the value of $I_{chr\,(Eq)\,0.8} / I_{chr\,(c)}$.

A third case can be considered. If we suppose that

$$I_{fl\,(NR,\,SR)\,0.8} < I_{fl\,(Eq)\,0.8}$$

then from relations (6a) and (6b) we have:

$$I_{chr\,(NR,\,SR)\,0.8} \leqslant I_{chr\,(Eq)\,0.8}\,.$$

We have tried to check the validity of this third case by direct measurements of the intensity of the chromospheric backround not only at distance $\sin\vartheta = 0.8$ from the center of the solar disk but also along the whole equatorial and polar radii of the sun from $\sin\vartheta = 0$ to $\sin\vartheta = 0.9$.

2. OBSERVATIONAL DATA AND MEASUREMENTS

The material used for this photometric study consists exclusively of spectroheliograms of the Arcetri Observatory (Table I). The spectroheliograph has an objective lens 15 cm. in diameter and of focal length 6.85 meters ; the average diameter of the focal plane is 63 mm, so that 1 mm on the plate corresponds to 30.5 sec. of arc. The theoretical resolving power of the objective lens of the telescope at 3933,7 Å (K line) is 0.66 sec of arc.

TABLE I

No	Plate	Date	No	Plate	Date
1	AC 119	22 - 6 - 1953	11	AD 293	2 - 10 - 1956
2	AC 228	6 - 10 - 1953	12	AD 309	12 - 10 - 1956
3	AC 336	15 - 4 - 1954	13	AD 655	19 - 4 - 1957
4	AC 680	10 - 8 - 1955	14	AD 706	13 - 5 - 1957
5	AC 998	12 - 5 - 1956	15	AE 105	19 - 9 - 1957
6	AD 71	14 - 6 - 1956	16	AE 132	3 - 10 - 1957
7	I 12	31 - 7 - 1956	17	AE 796	3 - 7 - 1958
8	II 5	8 - 8 - 1956	18	AF 641	20 5 - 1959
9	II 10	9 - 8 - 1956	19	AF 861	18 - 7 - 1959
10	AD 271	19 - 9 - 1956	20	AG 237	5 - 1 - 1960

TABLE II

$I_{chr}(\vartheta) / I_{chr}(c)$.

sin ϑ	O - W	O - E	O - N	O - S	Mean W, E	Mean N, S
0.0	1.000	1.000	1.000	1.000	1.000	1.000
0.1	0.988	0.981	0.997	0.992	0.984 ± 0.004	0.994 ± 0.002
0.2	0.978	0.966	0.988	0.977	0.972 ± 0.005	0.983 ± 0.002
0.3	0.957	0.942	0.974	0.960	0.950 ± 0.007	0.967 ± 0.003
0.4	0.927	0.912	0.954	0.943	0.919 ± 0.007	0.949 ± 0.004
0.5	0.887	0.876	0.929	0.914	0.881 ± 0.009	0.921 ± 0.005
0.6	0.836	0.833	0.892	0.888	0.834 ± 0.010	0.890 ± 0.007
0.7	0.733	0.777	0.852	0 854	0.775 ± 0.011	0.853 ± 0.008
0.82	0.676	0.692	0.797	0 797	0.684 ± 0.012	0.797 ± 0.010
0.9	0.598	0.613	0.729	0.734	0.606 ± 0.013	0.734 ± 0.013

All the photometrically callibrated spectroheliograms of the solar chromosphere have been taken in the ionised calcium line $K_{2,3,2}$ and with slit-widths 0.1 and 0.05 mm for the first and second slit respectively.

Since dispersion of the instrument is 3.35 Å/mm the band selected by the second slit is 0.17 Å centered at the core of K line. A UG3 filter was used for this spectroheliograms and each plate was calibrated by means of a Zeiis K58 photometric scale.

Four tracings were taken on each spectroheliogram in the W - E, N - S, NW - SE and NE - SW directions. These tracings concerned the quiet chromosphere away from centers of activity. As in a previous paper (Macris, 1974) the background was traced by the same process.

The W - E and N - S tracings were divided in ten equal parts from the center to the limb of the solar disk ($\sin\vartheta = 0.1$ to $\sin\vartheta = 1.0$). Then the ratios $I_{chr(\vartheta)} / I_{chr(c)}$ were measured. The mean values of these measurements for the 20 plates and for every sector as well as the mean values $\overline{N, S}$ and $\overline{W, E}$ are given in Table II. Figure 1 gives the variation of the ratio $I_{chr(\vartheta)} / I_{chr(c)}$ from the center to the limb of the solar disk in the W - E and N - S direction.

Figure 1 shows that the decrease of the intensity from the center to the limb in the N - S direction is smaller than that of the W - E direction. The chromospheric background is brighter near the polar regions than it is on the equator. At $\sin\vartheta = 0.82$ that is 55° the difference of the mean values $\overline{N, S}$ and $\overline{W, E}$ (Table II) is 0.113 ± 0.012.

This difference is not casual and as it is prooved by the Student's t-test (Fisher, 1946). The probability that the found differences are due to chance is very small ($p \leqslant 0.01$). Therefore there is a real reason which makes the intensity of the chromospheric background to be greater in the N - S than in the W - E direction.

The differences of the ratio $I_{chr(\vartheta)} / I_{chr(c)}$ between c - W and c - E as well as between c - N and c - S at the same distance from the center of the solar disk, are casual, as it has been prooved by the t-test ($p > 0.4$) and might be due to errors of the measurements. This is why we compared the mean values $\overline{W, E}$ and $\overline{N, S}$ (Table II).

A possible reason which can cause this intensity difference of the chromospheric background may be due to the second slit of the spectroheliograph which is straight while the K line is curved. It is therefore possible that the line $K_{2,3,2}$ passes strictly only about the center of the solar disk while in higher latitudes there is also light from other regions.

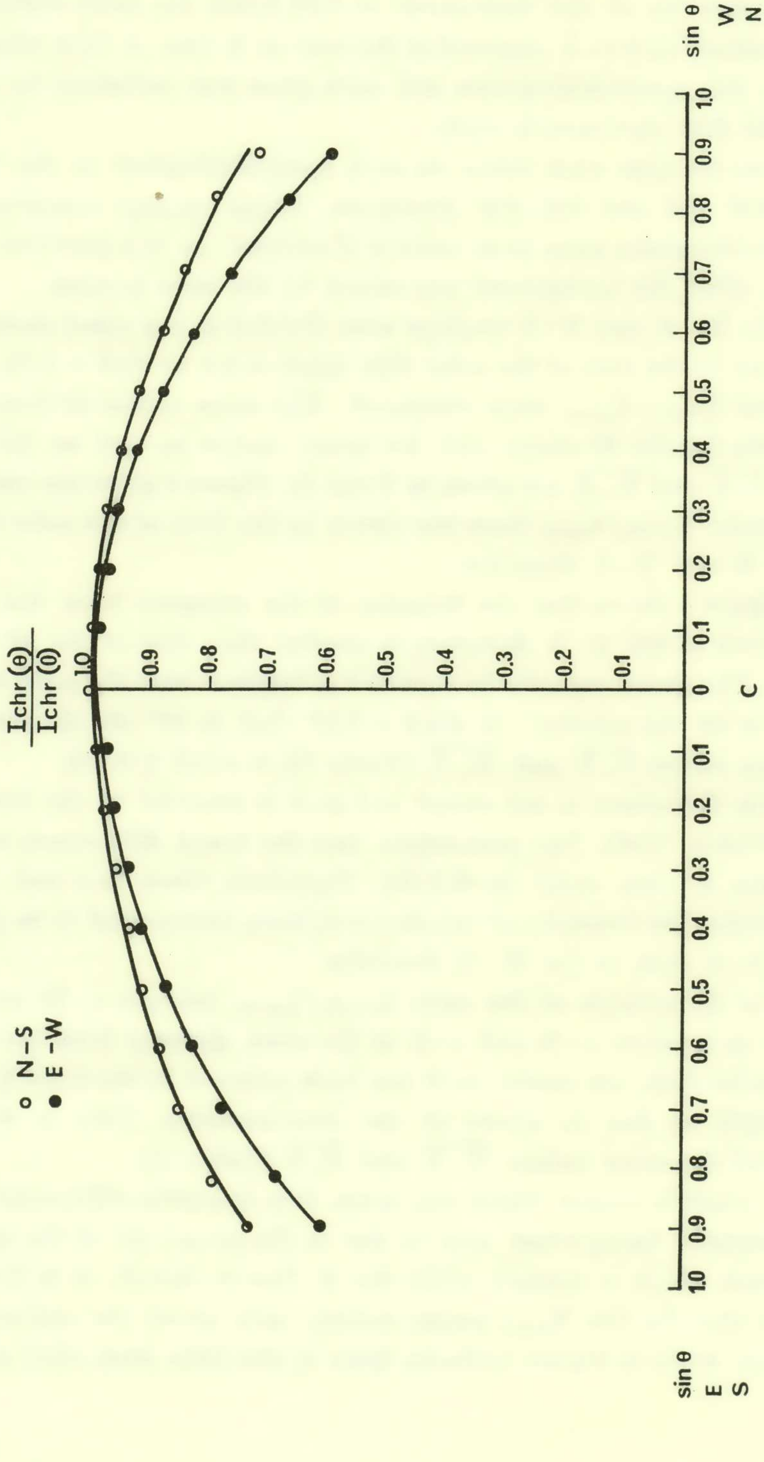

Fig. 1. The variation of the ratio $I_{chr(\theta)} / I_{chr(c)}$ from the center to the limb of the solar disk on the central meridian and on the equator.

To check whether this was true we took pairs of spectroheliograms with the second slit mooving in the W - E and in the perpendicular to the W - E direction. In both cases we had recordings of a solar region only through the central part of the second slit of the spectroheliograph. Then we measured the intensity differences for each pair of spectroheliograms and the results where the same as before.

Another reason which might cause this intensity difference is the vigneting effect if it is not uniformal on the disk. However we found out that it is symmetrical around the center of the solar disk.

Displacement of the line $K_{2,3,2}$ caused by the rotation of the sun is symmetrical in the c - E and c - W directions and therefore it does not influence the measurements.

Therefore there is great probability that the intensity difference of the chromospheric background in the N - S and W - E directions is due to a solar phenomenon.

Figure 2 illustrates the variation of the intensity difference $\overline{N, S} - \overline{W, E}$ with the heliographic latitude.

TABLE III

$\frac{I_{chr(\vartheta)}}{I_{chr(c)}}$, $\sin\theta = 0.82$.

N	W	NW	S	E	SE	N	E	NE	S	W	SW
0.797	0.676	**0.733**	0.797	0.692	**0.725**	0.797	0.697	**0.744**	0.797	0.676	**0.731**

The intensity of the chromosheric background in comparison to the intensity of the center, was measured in the NW - SE and NE - SW directions. The values we found are between those of the W - E and N - S directions. For example the intensity of the chromospheric background in distance $\sin\vartheta = 0.82$ in the c - NW, c - SE, c - NE and c - SW directions was found (Table III) to be between the values of the intensity in the c - W, c - E, c - N and c - S directions. Figure 3 presents the intensity variation of the cromospheric background at distance $\sin\vartheta = 0.82$ from the center of the solar disk in the clockwise direction.

3. INTENSITY VARIATION OF THE CHROMOSPHERIC BACKGROUND DURING THE SOLAR CYCLE

The spectroheliograms we used cover the interval 1953 - 1960, in which there is one minimum and one maximum of solar activity. Since

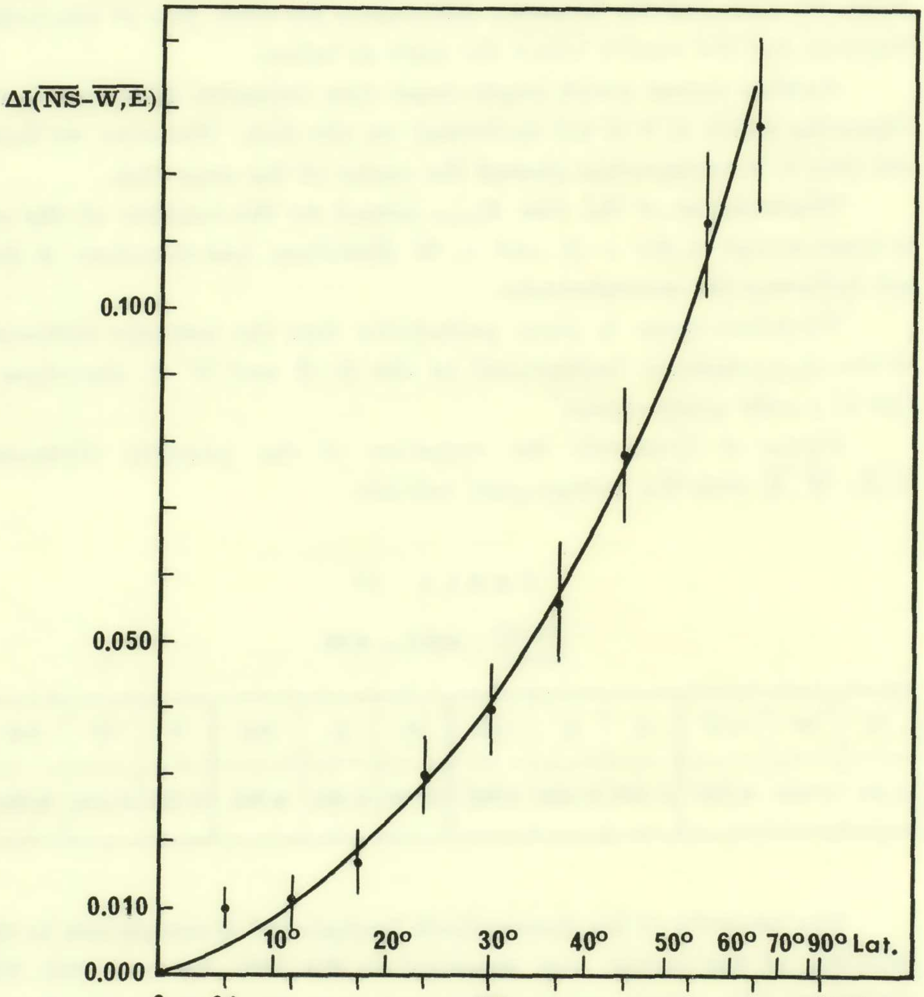

Fig. 2. The variation of the intensity difference ($\overline{N,S} - \overline{W,E}$) with the heliographic latitude.

we don't have too many plates (only 20) it is difficult to conclude whether the intensity of the chromospheric background varies during the solar cycle. Anyway we measured the intensity (mean values of the ratios

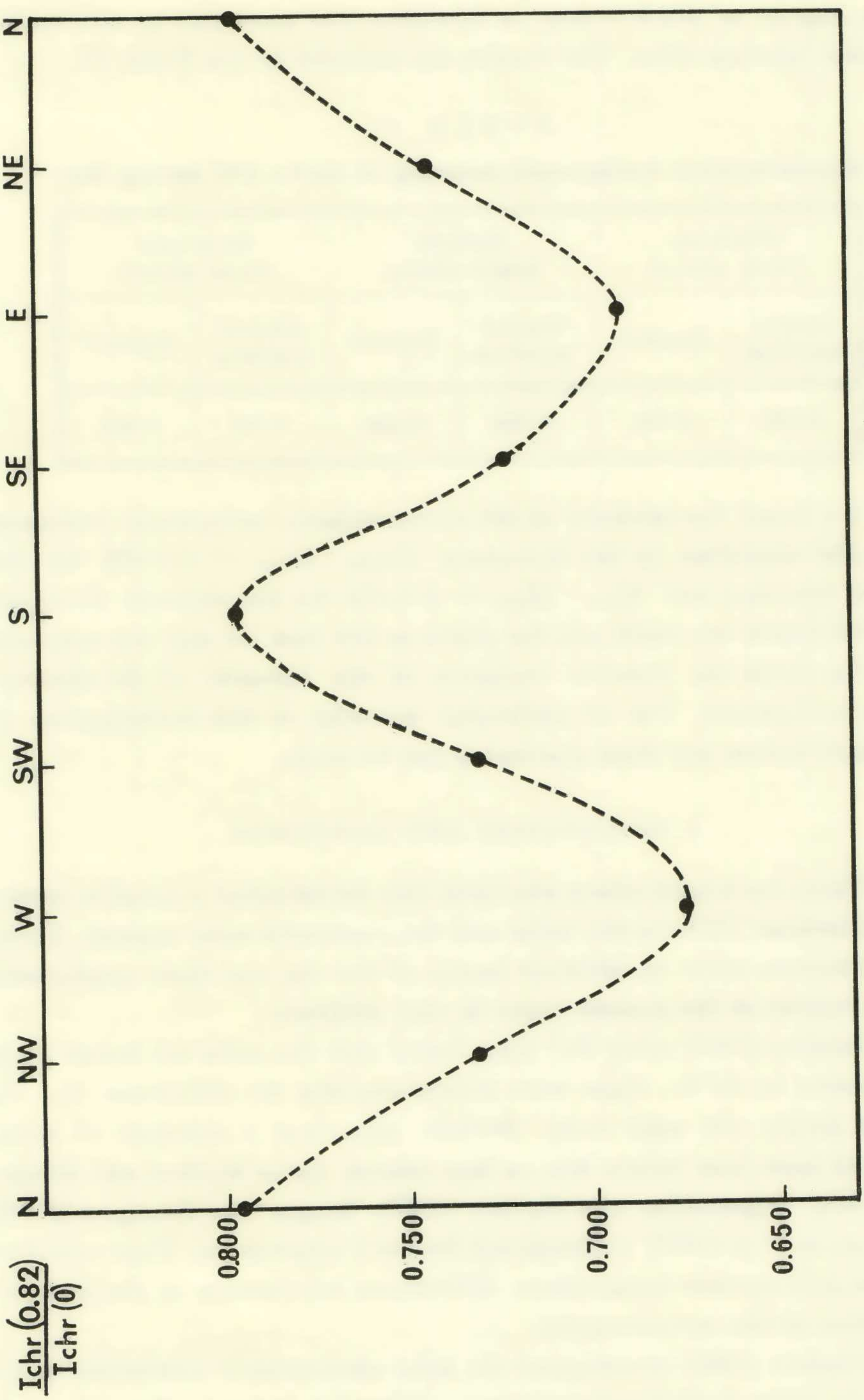

Fig. 3. The intensity variation of the chromospheric backround at distance sin ϑ = 0.82 from the center of the solar disk, in the clockwise direction.

$I_{chr(\vartheta)} / I_{chr(c)}$) at sim $\vartheta = 0.82$ in minimum and maximum as well as for one year between them. The results are included in the Table IV.

TABLE IV

Chromospheric background intensity at sin θ = 0.82 during the:

Minimum (three plates)		Medium (eight plates)		Maximum (three plates)	
Central meridian	Equator	Central meridian	Equator	Central meridian	Equator
0.820	0.736	0.802	0.694	0.798	0.658

We found the intensity of the chromospheric background decreases from the minimum to the maximum ($\Delta I_{min} - \Delta I_{max} = +0.022$ for the central meridian and $\Delta I_{min} - \Delta I_{max} = +0.078$ for the equator). However the differences are small and the plates so few that we may not conclude anything about the possible variation of the intensity of the chromosheric background. Use of additional material in this investigation is necessary before any final conclusion can be made.

4. CONCLUSIONS AND DISCUSSION

There have been others who have also investigated a possible intensity difference between the polar and the equatorial solar regions. Their measurements refer to different layers of the sun and their comparison to the results of the present paper is very difficult.

Beckers (1960) using Fe^{+} lines found that the poles are hotter than the equator by 60° K; there were indications that the difference $T_p - T_e$ varies during the solar cycle. Beckers also gives a summary of work that had been done before him on that subject. Later Mulders and Slaugter (1965), Apperzeller and Shröter (1967), Burger and Houtgast (1969) and Caccin et al (1970) contradicted Becker's conclusions. They considered the pole-equator temperature differences comparable to the statistical errors of the measurements.

Plaskett (1962) investigated the solar photospheric continuum spectrum in order to find a temperature difference between the polar and equatorial regions. These measurements have shown that the limb darkening is not described by the same law on the equator and on the polar regions. He concluded that the poles were hotter than the equator. In 1970 Plaskett's spectrophotometric measurements of surface brightness at $\lambda\, 6263$ Å for diametrically opposite limbs of the sun confirmed that the poles are at least five per cent brighter than the equatorial limb. Altrock and Canfield (1972) using photoelectric methods checked Plaskett's (1970) measurements, but they didn't confirm them. Michard (1962) measured the limb darkening at wave-legth $\lambda\, 5240$ Å of the continuum in both the equatorial and polar regions. According to his results there exists a systematic discrepancy between the poles and the equator, the pole being about 10° - 15° K hotter. However the author doesn't consider the result reliable because the probable error is of the order of the measured quantity.

A paper comparable to the present one is Das' and Abhyankar's (1960), who measured the equivalent widths of the spectral lines *g* and K at the minimum of activity near the poles and along the equator, especially close to the limb. They have evaluated the temperature difference between the polar and equatorial regions using Wooley's ionized calcium method; they found the poles $96^{\circ} \pm 18^{\circ}$ hotter than the equator. Our measurements concern the differences of chromoshperic intensity on $K_{2,3,2}$ spectroheliograms, that is in a layer of height about 1600 km in the solar atmosphere (Allen, 1973).

In a previous paper (Macris, 1967) we had found a difference of the $K_{2,3,2}$ chromospheric background, at distance $\sin\vartheta = 0.8$ from the center of the solar disk, between regions on the central meridian and the equator. In a recent paper (Macris, 1974) we found a difference of the ratio of the intensity of the flocculi to that at the chromospheric background on the polar and equatorial radii at the same distance $\sin\vartheta = 0.8$. Supposing that the flocculi intensity was constant at same distances from the center of the disk we concluded that $\Delta I_{chr\,(NR - Eq)\,0.8} = 0.045$ and $\Delta I_{chr\,(SR - Eq)\,0.8} = 0.058$. This means that the intensity of the chromospheric background on the central meridian at distance $\sin\vartheta = 0.8$ is greater than that of the equator. The direct measurements of the present study give a difference $\Delta I_{(\overline{NR},\, \overline{RS} - \overline{WE})\,0.82} = 0.113 \pm 0.012$ which is twice greater than the previous one. If this is true the flocculi intensity on the polar radii should be greater than that on the equatorial diameter. Therefore our second assumption at the begining of this work should be correct while the third one wrong.

The final conclusion is that there is a physical reason which causes the intensity change of the chromospheric background with heliographic lattitude and this is an interesting subject for further observational and theoretical investigations.

ACKNOWLEDGEMENTS

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I also wish to thank Mrs H. Dara for her valuable assistance at the present work, as well as Mr Th. Zachariadis for taking the microphotometric tracings I used.

Last but not least I would like to thank the Empirikion Foundation which supported this work.

ΠΕΡΙΛΗΨΙΣ

Εἰς τὴν παροῦσαν ἔρευναν μελετῶνται αἱ μεταβολαὶ τῆς ἐντάσεως τοῦ χρωμοσφαιρικοῦ βάθους $K_{2,3,2}$ κατὰ μῆκος τοῦ ἰσημερινοῦ (W - E) καὶ τοῦ κεντρικοῦ μεσημβρινοῦ (N - S) τοῦ Ἡλίου ἐκ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου καὶ μέχρις ἀποστάσεως ημ $\vartheta = 0.9$ ἐξ αὐτοῦ. Διὰ τὴν ἐργασίαν ταύτην ἐχρησιμοποιήθησαν 20 φασματοηλιογράμματα τοῦ Ἀστεροσκοπείου τοῦ Arcetri καλύπτοντα τὸ χρονικὸν διάστημα 1953 - 1960.

Τὰ ἐγγραφήματα, ληφθέντα διὰ τοῦ μικροφωτομέτρου Joyce τοῦ Κέντρου Ἐρευνῶν Ἀστρονομίας καὶ Ἐφηρμοσμένων Μαθηματικῶν τῆς Ἀκαδημίας Ἀθηνῶν, διηρέθησαν εἰς δέκα ἴσα τμήματα (ημ $\vartheta = 0.1$ ἕως ημ $\vartheta = 1.0$) ἐκ τοῦ κέντρου πρὸς τὸ χεῖλος τοῦ ἡλιακοῦ δίσκου καὶ ἐμετρήθησαν οἱ λόγοι $I_{chr(\vartheta)}/I_{chr(c)}$.

Τὰ ἀποτελέσματα ὑπῆρξαν τὰ ἀκόλουθα:

1) Ἡ ἔντασις τοῦ χρωμοσφαιρικοῦ βάθους εἶναι μεγαλυτέρα ἐπὶ τῶν πολικῶν ἀκτίνων.

2) Ἡ διαφορὰ ἐντάσεως μεταξὺ περιοχῶν κειμένων ἐπὶ τοῦ κεντρικοῦ μεσημ-

βρινοῦ καὶ τοῦ ἰσημερινοῦ καὶ εἰς τὴν αὐτὴν ἀπὸ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου ἀπόστασιν, αὐξάνει μετὰ τοῦ ἡλιογραφικοῦ πλάτους.

3) Ὑπάρχουν ἐνδείξεις ὅτι ἡ ἔντασις τοῦ χρωμοσφαιρικοῦ βάθους, τόσον ἐπὶ τοῦ κεντρικοῦ μεσημβρινοῦ ὅσον καὶ ἐπὶ τοῦ ἰσημερινοῦ, μεταβάλλεται συναρτήσει τοῦ κύκλου τῆς ἡλιακῆς δραστηριότητος. Ἡ μεταβολὴ εἶναι ἀντίστροφος. Τὸ ἐν λόγῳ συμπέρασμα δὲν δύναται νὰ γίνῃ μετὰ βεβαιότητος ἀποδεκτόν, λόγῳ τοῦ μικροῦ ἀριθμοῦ τῶν χρησιμοποιηθέντων φασματοηλιογραμμάτων.

Αἱ εὑρεθεῖσαι τιμαὶ τῶν διαφορῶν τῶν ἐντάσεων τοῦ χρωμοσφαιρικοῦ βάθους μεταξὺ κεντρικοῦ μεσημβρινοῦ καὶ ἰσημερινοῦ ἀπεδείχθη ὅτι ὀφείλονται εἰς συστηματικὴν αἰτίαν. Κατελήξαμεν εἰς τὸ συμπέρασμα ὅτι ἡ προκαλοῦσα τὰς διαφορὰς ταύτας αἰτία ὀφείλει νὰ ἑδρεύῃ ἐπὶ τοῦ Ἡλίου. Ἡ ἀποκάλυψις τῆς αἰτίας ἥτις προκαλεῖ τὸ τόσον ἐνδιαφέρον τοῦτο φαινόμενον, ἀποτελεῖ λίαν ἐνδιαφέρον πρόβλημα τῆς ἡλιακῆς φυσικῆς, θέλει δὲ μελετηθῇ μελλοντικῶς.

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Κατὰ τὴν ἀνακοίνωσιν τῆς ἐργασίας «Ἐπὶ τῆς διαφορᾶς τῆς ἐντάσεως τοῦ χρωμοσφαιρικοῦ βάθους ἐπὶ τῶν πολικῶν καὶ τῶν ἰσημερινῶν ἀκτίνων τοῦ ἡλιακοῦ δίσκου» ὁ Ἀκαδημαϊκὸς κ. **Ἰωάννης Ξανθάκης,** εἶπε τὰ ἀκόλουθα.

Ἡ διαφορὰ ἐντάσεως καὶ θερμοκρασίας μεταξὺ πολικῶν καὶ ἰσημερινῶν περιοχῶν ἀπησχόλησε τοὺς ἡλιακοὺς φυσικούς, ἀλλὰ τὰ ἀποτελέσματα τῶν ἐρευνῶν ὑπῆρξαν ἀντιφατικά. Οἱ πλεῖστοι ἐξ αὐτῶν εἰργάσθησαν ἐπὶ τῆς κατωτάτης στιβάδος τῆς ἡλιακῆς ἀτμοσφαίρας, δηλαδὴ τῆς φωτοσφαίρας, ἐχρησιμοποίησαν δὲ διαφόρους μεθόδους, ἄλλαι τῶν ὁποίων ἔδωσαν θετικὰ καὶ ἄλλαι ἀρνητικὰ ἀποτελέσματα.

Ἡ παροῦσα ἔρευνα ἀναφέρεται εἰς τὴν ἀπ' εὐθείας μέτρησιν τοῦ χρωμοσφαιρικοῦ βάθους $K_{2,3,2}$. Ὁ κ. Μακρῆς ἐχρησιμοποίησε τὰ φασματοηλιογράμματα τοῦ Ἀστεροσκοπείου τοῦ Arcetri τῆς Φλωρεντίας. Χρησιμοποιήσας τὸ φωτοηλεκτρικὸν μικροφωτόμετρον Joyce τοῦ Κέντρου Ἐρευνῶν Ἀστρονομίας καὶ Ἐφηρμοσμένων Μαθηματικῶν τῆς Ἀκαδημίας Ἀθηνῶν ἔλαβε μεγάλην σειρὰν ἐγγραφημάτων κατὰ τὰς διευθύνσεις τοῦ κεντρικοῦ μεσημβρινοῦ (N - S) καὶ τοῦ ἰσημερινοῦ (W - E) καὶ ἐμελέτησε τὸν λόγον τῆς ἐντάσεως τοῦ χρωμοσφαιρικοῦ βάθους πρὸς τὴν ἔντασιν αὐτοῦ εἰς τὸ κέντρον τοῦ ἡλιακοῦ δίσκου, εἰς ὅλα τὰ ἡλιογραφικὰ πλάτη καὶ μήκη. Τὰ ληφθέντα ἀποτελέσματα ὑπῆρξαν λίαν ἐνδιαφέροντα καὶ δύνανται νὰ συνοψισθῶσι ὡς ἀκολούθως :

1) Αἱ τιμαὶ τῶν λόγων αὐτῶν ἔδειξαν σαφῶς ὅτι ἡ ἔντασις τῆς ἠρέμου χρωμοσφαίρας, ληφθείσης διὰ τῆς γραμμῆς $K_{2,3,2}$ τοῦ ἰονισμένου ἀσβεστίου, εἶναι μεγαλυτέρα ἐπὶ τοῦ κεντρικοῦ μεσημβρινοῦ ἀπὸ ἐκείνην τοῦ ἰσημερινοῦ.

2) Αἱ διαφοραὶ τῶν ἐντάσεων τοῦ χρωμοσφαιρικοῦ βάθους, μεταξὺ κεντρικοῦ μεσημβρινοῦ καὶ ἰσημερινοῦ καὶ εἰς τὰς ἰδίας ἀπὸ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου ἀποστάσεις, αὐξάνουν μετὰ τοῦ ἡλιογραφικοῦ πλάτους.

3) Ὑπάρχουν ἐνδείξεις μεταβλητότητος τῆς ἐντάσεως τοῦ χρωμοσφαιρικοῦ βάθους συναρτήσει τοῦ κύκλου τῆς ἡλιακῆς δραστηριότητος, τῆς πορείας οὔσης ἀντιστρόφου.

Ἡ ἐφαρμογὴ τῶν στατιστικῶν κριτηρίων σημασίας (test-t τοῦ Student) δεικνύει ὅτι αἱ εὑρεθεῖσαι διαφοραὶ δὲν εἶναι τυχαῖαι, ἀλλὰ ὀφείλονται εἰς συστηματικόν τι αἴτιον μὴ δυνάμενον νὰ ἀποδοθῇ εἰς τὸ χρησιμοποιηθὲν ὄργανον. Οὕτω κατέληξεν εἰς τὸ συμπέρασμα ὅτι τὸ αἴτιον τὸ προκαλοῦν τὸ ἀνωτέρω φαινόμενον δέον νὰ ἑδρεύῃ ἐπὶ τοῦ Ἡλίου.