ΑΣΤΡΟΝΟΜΙΑ.— **Photometric research for the $K_{2,3}$ chromospheric Flocculi,** *by Constantin J. Macris**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ι. Ξανθάκη.

A b s t r a c t. The photometric study of the small emission centers of the $K_{2,3}$ solar chromosphere (flocculi), based on a series of spectroheliograms (1953 - 1959) of the Arcetri Observatory, enabled us to estimate the mean value of the intensity of the flocculi ($I_{fl(0)}$) relatively to the mean value of the intensity of the chromospheric background at the center of the solar disk ($I_{chr(0)}$). The ratio $I_{fl(0)} / I_{chr(0)}$, after the appropriate corrections was found to be 1,482 $\pm$ 0,003.

The measurements at distance $\sin\vartheta = 0.8$ from the center of the solar disk on the equatorial and polar radii showed that the difference, of the ratio I_{fl} / I_{chr}, is significant. If this difference is not due to an error of the Arcetri spectroheliograph, it might be due to a physical reason which we will try to find out.

1. INTRODUCTION

Spectroheliograms of the solar chromosphere in the H and K lines of CaII have been studied for many years (e. g. Deslandres 1910, d' Azambuja 1930). The long living bright features, faculae and flocculi are of particular interest. By «flocculi» we mean the coarse bright mottles which emit monochromatic radiation and are distributed, more or less uniformely all over the solar disk ; they form a cellular network with characteristic size of about 30000 km and they are located along the perimeter of the cells. As it is well known, the chromospheric spicules are also closely associated with the network.

The bright flocculi are the basic constituent of the K chromosphere, therefore their study is considered indispensable. The mean lifetime of the flocculi is 9 hours and for some of them over 50 hours (Macris 1956, 1962, Janssens 1970). They are clossely associated to the local magnetic fields (Zirker 1955), which, within the present resolution of the magneto-

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graphs, have an intensity of the order of 1 to 10 Gauss and a direction nearly perpendicular to the surface.

Despite the fact that the K chromosphere has been observed over many years there are not many photometric studies. Several years ago Rogerson (1955) made a photometric study on the intensity fluctuations in Ha and CaII K spectroheliograms that were obtained during the minimum of solar activity and were very few. Photometric studies of the photospheric faculae have been made by Richardson (1933) in two spectral regions (4500 Å and 5780 Å) and by Wormel (1936) again in white light. The results refer to faculae near the limb ($\sin\vartheta > 0,6$) and not near the center of the disk where they are not observable.

We considered worthwhile to start a photometric study of the bright flocculi of the K chromosphere. The subject of the present paper is the intensity of the flocculi I_{fl} in comparison to that of the chromospheric background I_{chr} reduced to the center of the solar disk. The measurements refer to features with size varying from 7 to 45 seconds of arc and an average size of about 25 seconds.

2. OBSERVATIONAL MATERIAL AND DATA PROCESSING

The material used for this photometric study is consisted exclusively of spectroheliograms of the Arcetri observatory; these photometrically callibrated plates were taken in the ionised calcium line $K_{2,3}$. The spectroheliograph has an objective lens with a diameter of 15 cm, and a focal length of 6.85 metres; 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.

The plates used are Ferrania Verde (Normal Panchro Rapid), except for plate AF 276 (Kodak EIVO). Table I is a list of the plates which were used for the present study. The first column contains the caracteristic number of the Arcetri plates, the second the dates on which they were taken, the third gives information about the quality of the plates; the fourth and fifth columns give the diameter of the image and the type of emulsion, respectively.

The plates selected cover the period 1953 - 1959. The year 1953 was

TABLE I

No	Characteristic Number	Date	Quality *	Diameter in mm.	Emulsion
1	AC 185	19 - 8 - 1953	5	63	Ferrania-Verde
2	228	6 - 10 - 1953	5	63	»
3	234	9 - 10 - 1953	4	63	»
4	328	9 - 4 - 1954	5	63	»
5	361	18 - 6 - 1954	5	62	»
6	489	15 - 11 - 1954	4	64	»
7	601	24 - 5 - 1955	3	63	»
8	727	2 - 10 - 1955	4	63	»
9	749	14 - 10 - 1955	4	63	»
10	947	9 - 4 - 1956	4	63	»
11	AD 71	14 - 6 - 1956	4	62	»
12	271 A	19 - 9 - 1956	5	63	»
13	271 B	19 - 9 - 1956	5	63	»
14	293	2 - 10 - 1956	5	63	»
15	622	5 - 4 - 1957	4	63	»
16	980	8 - 8 - 1957	5	63	»
17	AE 120	27 - 9 - 1957	5	63	»
18	202	16 - 10 - 1957	4	63	»
19	204	17 - 10 - 1957	5	63	»
20	205 A	17 - 10 - 1957	5	63	»
21	205 B	17 - 10 - 1957	5	63	»
22	AF 99	18 - 9 - 1958	4	63	»
23	527	3 - 4 - 1959	5	63	KODAK EIVO

* Quality is expressed in a scale from 1 to 5.

chosen because before that year the plates were placed in the spectroheliograph at some distance behind the second slit and the resulting diffused light from the grating was too intense to be negligible. In 1953, the spectroheliograph was adjusted so that the plate was practically in contact with the second slit; thus the diffuse light was reduced to the minimum.

All the spectroheliograms of the solar chromosphere have been taken in the ionised calcium line $K_{2,3}$ and with slit-widths 0.1 and 0.05 mm for the first and second slit, respectively. Since the dispersion of the instrument is 3.35 Å/mm the band selected by the second slit is 0.1675 Å centered at the core of K line. A UG3 filter was used for these spectroheliograms, and each plate was calibrated by means of a Zeiss K 58 photometric scale.

The intensity of the emmission features in comparison with the intensity of the quiet chromospheric background has been determined by the recording microphotometer of the Arcetri observatory, which measures the transparensy of the plate and records it on a 25 cm wide chart. A spot of 0.08 mm diameter falls on the plate; the variations of the intensity of the light due to the plate absorption are measured by a photomultiplier, which is either 931A or 1P21 type.

As it has already been mentioned the diameter of the circular spot of the microphotometer was 80 microns. Since the flocculi we measured had a diameter over 7 seconds of arc, which corresponds to about 200 microns on the plates, it is obvious that the size of the spot was suitable even for the smallest flocculi.

Out of the thirty tracings of each plate, ten were taken near the equator from the center of the disk to the limb, and ten near the polar regions from 48 to 58 degrees solar latitude. Near the polar regions the whole image of the solar disk was scanned in the East-West direction. The spectroheliograms were taken in the direction of motion of the spectroheliograph i. e. parallel to the equator. The chariot of the spectroheliograph was placed in such a way that the largest dimension of the plate (9 $\times$ 12 cm) was parallel to the E-W direction, and perpendicular to the N-S direction of the sun, because the picture had been taken with the same orientation. Figure 1 shows a $K_{2,3}$ picture of the solar chromosphere, the direction of motion of the plate carrier, and the perpendicular to the largest dimension of the plate N - S axis. Microphotometric recordings have been made in the quiet chromosphere, away from

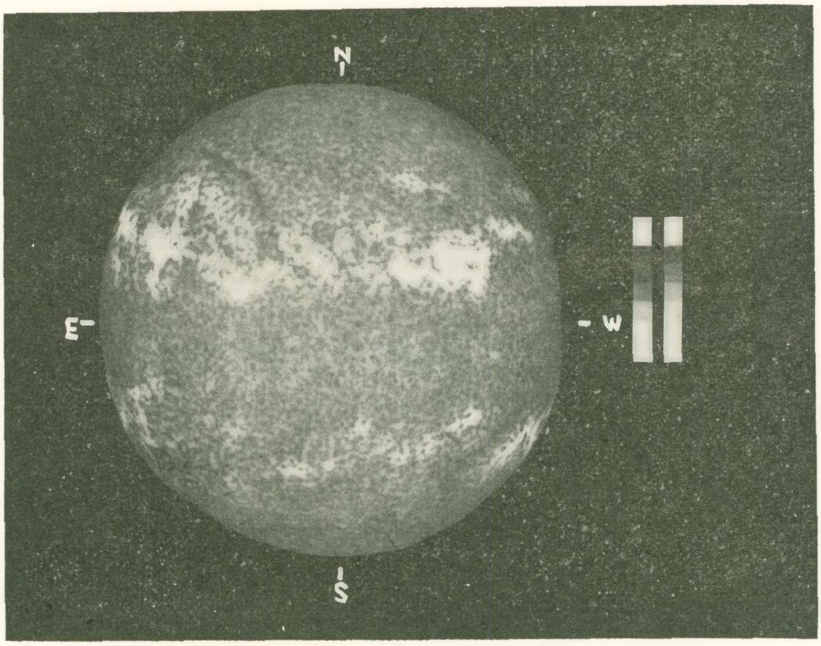

Fig. 1. $K_{2,3}$ chromospheric spectroheliogram. The carrier moves in the E - W direction.

centers of activity. The width of the measured regions of the sun, both polar and equatorial, was 2,5 mm (Figure 2). It is obvious that near the polar regions the real width of a measured zone, because of the foreshortening effect, is larger than that of an equatorial zone. Each tracing was taken by displacing the carrier of the plate by 0,25 mm. That is after having moved the plate in the AB direction and having obtained the respective tracing the carrier was displaced by 0,25 mm and was then moved back in the CD direction. This was repeated for the rest of the recordings and after this process tracings were taken for the 6 steps of the photometric wedge.

Since the recordings in the polar regions were taken in the

E-W direction the size of the flocculi was not affected by foreshortening; in the N-S direction, however, the flocculi were foreshortened and appeared smaller, when they were away from the center. Thus an average flocculus, having a diameter of 25 seconds of arc appeared unchanged in

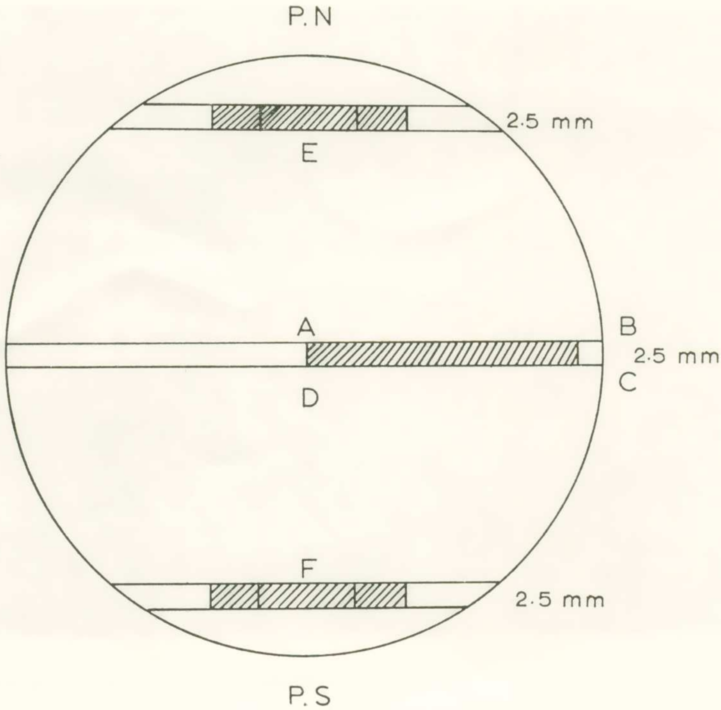

Fig. 2. Areas measured and mode of measurement.

the E-W direction, while in the N-S direction it was foreshortened with respect to the latitude, which in our case was of the order of 53 degrees. At this latitude, it appeared to have a diameter of 14 seconds. Since, as already mentioned, the diameter of the spot of the microphotometer was 0.08 mm, which corresponds to 2.4 seconds of arc on the spectroheliogram, we had no problem, and it was possible to extend our photometric measurements to the smallest flocculi.

The mean radius of the disk on the spectroheliograms was 31,5 mm and the magnification factor of the microphotometer 3,345. Thus the recorded length of one solar radius of the chart, was 105,4 mm.

A curve such as that of Figure 3 is a microphotometric tracing, parallel to the solar equator and illustrates the limb darkening of the background. In certain cases the transmission is higher than usual and the recorder will give a tracing, which will be below the normal limb

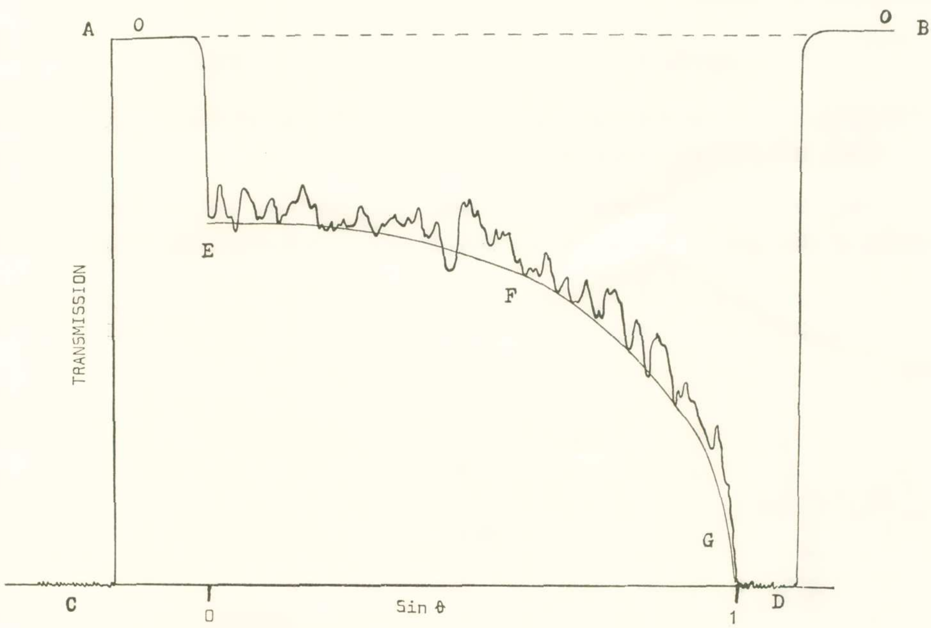

Fig. 3. Center to limb recording parallel to the solar equator.

darkening. This may be due to minor prominences projected on the disk. This has been taken into consideration for the plotting of the limb-darkening curves.

At first we used 23 spectroheliograms to measure 2370 flocculi, scanning from the center of the disk to 0,9 solar radii from the limb on the equator. The ratio $n = I_{fl} / I_{chr}$, where I_{fl} is the intensity of the flocculus and I_{chr} the intensity of the surrounding chromospheric background, was calculated by using the calibration curve of the plate.

The flocculi of the polar regions have been measured in the same way. All the flocculi in the region E and F (Figure 2) were measured and those in the shadowed area were selected. The flocculi in these areas lay near, and on both sides of the central meridian, between latitudes 48 and 58 degrees.

The ratios I_{fl} / I_{chr} were corrected for the errors of the recording microphotometer, and those due to stray light in the spectroheliograph. In the next chapter we shall discuss the necessary corrections for the instrumental errors.

3. CORRECTIONS OF THE MEASUREMENTS

A. CORRECTION OF ERRORS DUE TO THE MECHANICAL INERTIA OF THE MICROPHOTOMETER RECORDER.

Our first concern was to evaluate and correct errors due to the inertia of the pen of the recorder which could influence the response of

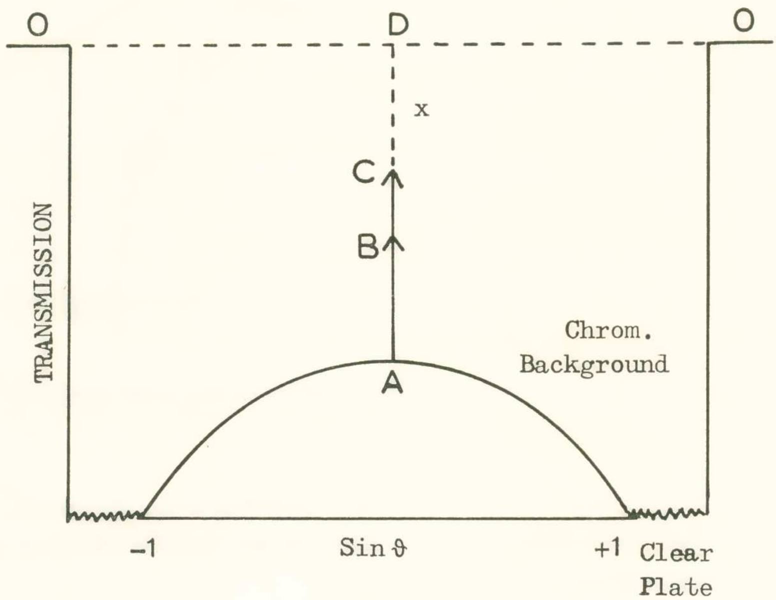

Fig. 4. Correction of the error due to mechanical inertia of the microphotometer.

the instrument. Since the area of the plate illuminated by the spot was comparatively small, and the spot moved with a considerable velocity, the response of the recording pen was smaller than it should be by quite an important factor. This was so because the pen was not given sufficient time to reach its maximum deviation.

To illustrate this, let us consider a tracing of a chromospheric spectroheliogram (Figure 4); AB is the actual deviation of the recording pen, when the image of a flocculus moves with a certain velocity before the spot of the microphotometer. The actual deviation should presumably have been larger, that is AC; it is necessary therefore to determine the quantity $DC = x$, which, when divided by the interval zero-clear plate, will give the transmission of point C. The distances DB and DA are determined by direct measurement and $x = DA - CA$. But $CA = k . AB$, where, k, is the factor which multiplied by the deviation AB of the pen will give the actual deviation without time-lag and inertia effects. We have, accordingly: $x = DA - k . AB$.

To determine k we proceeded as follows. A transparent glass scale with rules of the same thickness was been passed in front of the spot at different velocities. For every velocity, we measured the width of the tracing on the chart and the respective deviation of the pen, which corresponded to one rule. When the size of a feature is sufficiently large, for a given velocity of the plate before the spot, the deviation of the recording pen will give the true value.

TABLE II

Diameter of features in mm.	Factor K	Diameter of features in mm.	Factor K
0,7	3,31	1,6	1,06
0,8	2,28	1,7	1,04
0,9	1,74	1,8	1,03
1,0	1,41	1,9	1,02
1,1	1,22	2,0	1,01
1,2	1,15	2,1	1,01
1,3	1,11	2,2	1,00
1,4	1,08	2,3	1,00
1,5	1,06	2,4	1,00

The values of the factor k for chromospheric features having a diameter of 0.7 mm or more are given in Table II. This table shows that, when the diameter of a flocculus on the spectroheliograms exceeds the value of 2 mm, the deviation of the recorder is the true one and no correction is necessary.

Thus after measuring the deviation of the pen for each flocculus (measurements made on the first negative plate) as well as the diameters of the flocculi, we made the necessary corrections to obtain the true deviation of the pen, i. e. the true distance between the maximum deviation point and the zero point of the tracing. This distance divided by the distance between zero point and clear-plate point, gave us the transmission for each flocculus. From the calibration curve of each spectroheliogram we obtained the log I, and finally the ratio n. The mean error for n is ± 0.003; to determine this error we procede as follows.

A tracing was obtained by moving the spectroheliogram in the microphotometer in the E - W direction (Figure 1). Then the motion was reversed without displacing the plate and another tracing was obtained moving in the W - E direction. As expected the same flocculi were traced on both of these tracings. However if we determine the ratio n for each pair of measurements corresponding to the same flocculus, we see that these two values of n differ. This may be attributed both to possible mechanical irregularities of the microphotometer and to the drawing of the line of the quiet chromospheric background, which is not identical in these two cases. These discrepancies of the ratio n were measured for 152 pairs of flocculi tracings and the mean error was determined through the relation $E_m = \sqrt{\dfrac{\Sigma U^2}{m(m-1)}} = 0.003.$

B. CORRECTION FOR THE SCATTERED LIGHT.

After the corrections for the inertia of the recorder the measurements were corrected for the effect of scattered light in the spectroheliograph. The intensity of the scattered light was obtained by measuring the intensity of the chromosphere at the center of the disk in two spectroheliograms, one at $K_{2,3}$ and another in the continuum at near 3950 Å, obtained under identical conditions (Ballario, 1950). The observed ratio was $I_{K_{2,3}} / I_{3950} = 0.11$. This value was compared with the observations of the K profile by White and Suemoto (1968); their measurements were integrated over the wavelenth interval of 0.1675 Å that passes through the second slit. This gave $I_{K_{2,3}}/I_{3950} = 0.056$. Obviously the intensity of the scattered light is $C/I_{3950} = 0.054$.

The intensity of the scattered light depends on the shape of the line profile at the wings and on the spectroheliograph. Since the profile of the chromosphere at the wings of the K line is not very different from that of the flocculi, it is reasonable to assume that the intensity of the scattered light is the same for both the flocculi and the chromospheric background. Then we may write.

$$n_{true} = \left(\frac{I_{fl}}{I_{chr}}\right)_{true} = \frac{(I_{fl})_{obs} - C}{(I_{chr})_{obs} - C}$$

or
$$n_{true} = \frac{n_{obs} - C/(I_{chr})_{obs}}{1 - C/(I_{chr})_{obs}} . \qquad (1)$$

The value of the ratio $C/(I_{chr})_{obs}$ at the center of the disk is

$$b = \frac{C}{(I_{chr})_{obs}} = \frac{C}{I_{3950}} \Big/ \frac{(I_{chr})_{obs}}{I_{3950}} = 0.50.$$

Therefore finally

$$n_{true} = \frac{n_{obs} - 0.50}{0.50} . \qquad (2)$$

The above correction b is valid only for the center of the solar disk. However the ratio I_{fl}/I_{chr} has been measured along the equatorial radius from the center to $\sin\vartheta = 0.9$. Therefore we should examine the possible change of the correction as we move from the center to the limb. At first we examine the change of the ratio $I_{chr(\vartheta)}/I_{(\vartheta)}$ from $\sin\vartheta = 0$ to $\sin\vartheta = 0.9$.

This ratio is given by the relation

$$\frac{I_{chr(\vartheta)}}{I_{(\vartheta)}} = \frac{I_{chr(0)}}{I_{(0)}} \cdot \frac{I_{(0)}}{I_{(\vartheta)}} \cdot \frac{I_{chr(\vartheta)}}{I_{chr(0)}} \qquad (3)$$

where $I_{chr(\vartheta)}$ is the intensity of the chromospheric background in $K_{2,3}$ at a distance ϑ from the center of the disk, $I_{(\vartheta)}$ is the intensity of the continuum at a distance ϑ from the center of the disk, $I_{chr(0)}$ is the intensity of the chromospheric background in $K_{2,3}$ at the center of the disk and $I_{(0)}$ the intensity of the continuum at the center of the disk.

1) $\frac{I_{chr(0)}}{I_{(0)}}$, the ratio of the intensity of the chromospheric background to the intensity of the continuum at 3950 Å at the center of the disk has been found to be 0.110.

2) The ratio $\frac{I_{(0)}}{I_{(\vartheta)}}$ of the intensity of the continuum at the center of the disk and at the distance ϑ from the center as given by Unsöld (1955) $I_{(\vartheta)} = I_{(0)}\left(\frac{1 + b_0 \cos\vartheta}{1 + b_0}\right)$. For $\lambda = 3950$ Å, b_0 is 2.83.

TABLE III

$\sin\vartheta$	$\frac{I_{chr(\vartheta)}}{I_{chr(0)}}$	$\frac{I_{fl(\vartheta)}}{I_{chr(\vartheta)}}$	$\frac{I_{fl(\vartheta)}}{I_{chr(\vartheta)}} \Big/ \frac{I_{fl(0)}}{I_{chr(0)}}$	$\frac{I_{fl(\vartheta)}}{I_{fl(0)}}$
0.0	1.000	1.346	1.000	1.000
0.1	0.996	1.346	1.000	0.996
0.2	0.986	1.346	1.000	0 986
0.3	0 968	1.350	1.003	0.971
0.4	0.937	1.358	1.009	0.942
0.5	0.878	1.369	1.017	0.893
0.6	0.820	1.385	1.022	0.838
0.7	0.745	1.404	1.043	0.777
0.8	0.650	1.427	1.060	0.689
0.9	0.512	1.454	1.080	0.553
0.92	0.458			
0.94	0.424			
0.96	0.375			

3) $\frac{I_{cnr(\vartheta)}}{I_{chr(0)}}$, the ratio of the intensity of the chromospheric background in $K_{2,3}$ at distance ϑ from the center of the disk to the same intensity at the center. This ratio follows the law of limb-darkening. To determine the limb darkening we selected the spectroheliograms AC 228, AC 459, and AC 947. The tracings of the microphotometer were taken by scanning the plates from the center along the solar equator to a distance where $\sin\vartheta = 0.96$; for values of $\sin\vartheta$ 0.90 the results

are not very reliable. The values of the ratio $\frac{I_{chr(\vartheta)}}{I_{chr(0)}}$ are given in the first column of the Table III and their plotting versus $\sin\vartheta$ is illustrated in Figure 5.

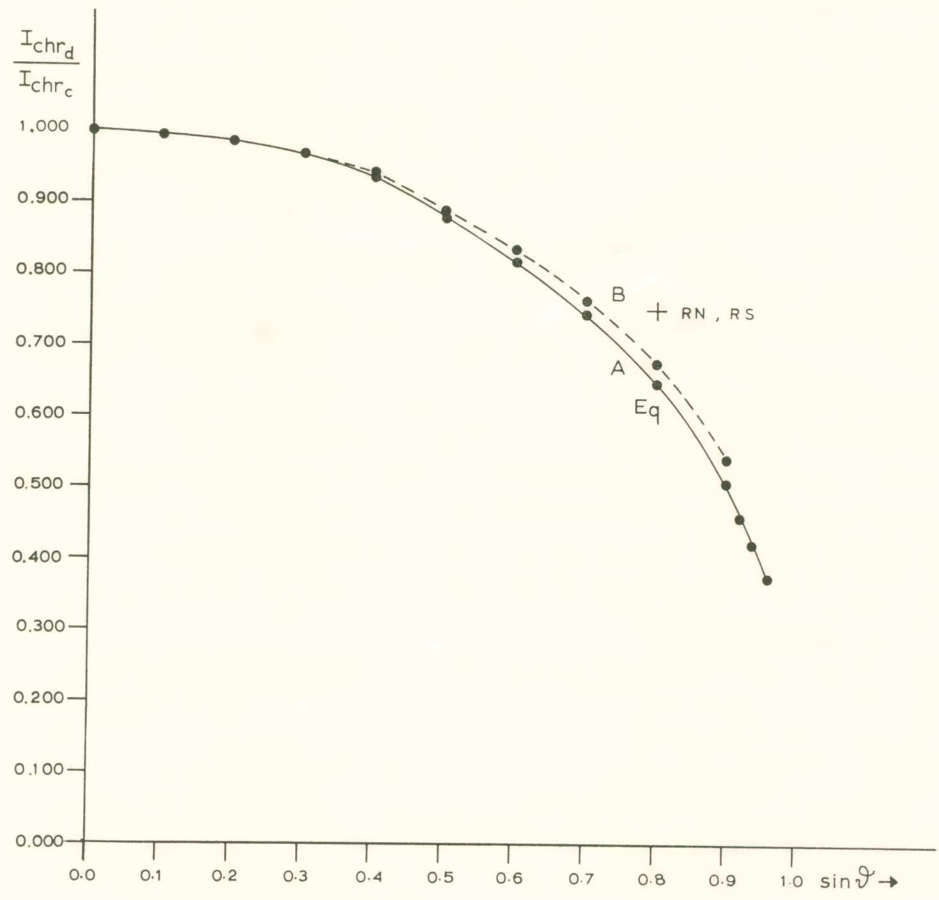

Fig. 5. Center-to-limb darkening of the chromospheric background in $K_{2,3}$.

Relation (3) gives the ratio $\frac{I_{chr(\vartheta)}}{I_{(\vartheta)}}$. From this relation we found the change of the above ratio along the equatorial solar radius. The values of the ratio at $\sin\vartheta = 0.9$ and at the center of the disk differ only by 0.005. Therefore the correction $b = C / (I_{chr})_{obs}$ of the relation (1) can be considered independent of the position on the disk.

4. PHOTOMETRY OF THE FLOCCULI IN THE EQUATORIAL ZONE

A. VARIATION OF I_{fl} / I_{chr} FROM THE CENTER TO THE LIMB.

After the corrections described in section 3 were applied to the ratio n, the variation of the intensity of the flocculi along the equatorial radius was studied. Back in 1930, L. d' Azambuja by visual inspection of the K spectroheliograms concluded that, while the chromospheric background has an appreciable limb darkening, the brightness of the chromospheric flocculi appears unchanged, without a similar limb effect.

At first, the intensity of the flocculi with respect to the local chromospheric background was measured. For this purpose the tracings of the equatorial zone were devided in seven sections at various distances from the center of the disk. The values I_{fl} / I_{chr} were measured for the flocculi of each section and after the appropriate corrections the mean value of I_{fl} / I_{chr} was calculated for each section. The results are shown in Table IV and are plotted in Figure 6. The maximum distance from the center of the disk corresponds to $\sin\vartheta = 0.9$. As already mentioned, beyond this distance the results become unreliable. The last column of Table IV gives the values of a smooth curve that was fitted to the measurements. We notice that the contrast of flocculi increases with heliocentric distance.

TABLE IV

$\sin\vartheta$	Number of flocculi measured	$\left(\frac{I_{fl(\vartheta)}}{I_{chr(\vartheta)}}\right)_{(mes)}$	$\left(\frac{I_{fl(\vartheta)}}{I_{chr(\vartheta)}}\right)_{(calc)}$
0.00 - 0.15	252	1.347	1.347
0.15 - 0.30	288	1.350	1.347
0.30 - 0.45	364	1.351	1.355
0.45 - 0.60	454	1.374	1.373
0.60 - 0.70	312	1.391	1.394
0.70 - 0.80	374	1.427	1.415
0.80 - 0.90	326	1.435	1.440

In order to obtain the intensity of flocculi at an angle ϑ, with respect to the intensity of the flocculi at the center of the disk (that is

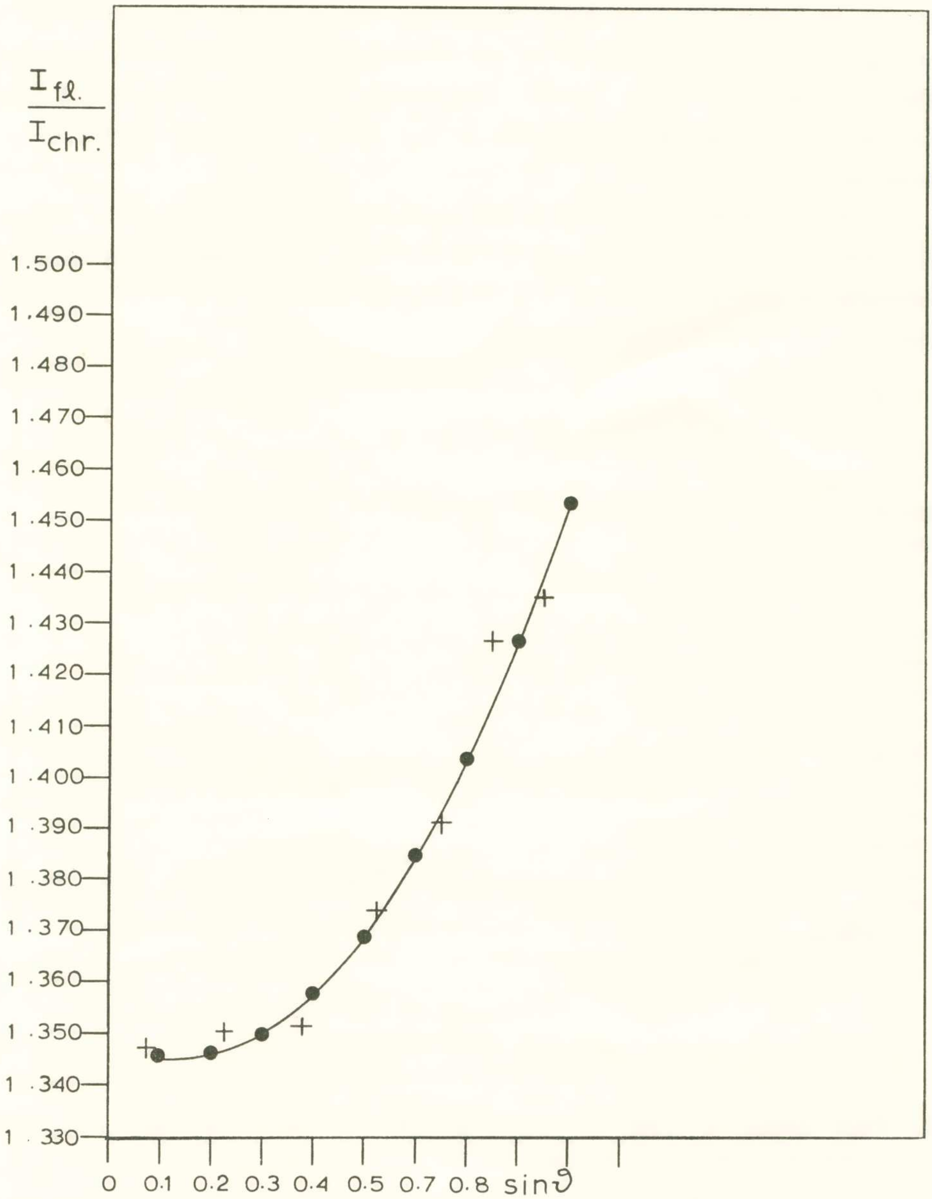

Fig. 6. Variation of the ratio I_{fl} / I_{chr} as a function of sin ϑ.

the function $I_{fl(\vartheta)} / I_{fl(0)}$) the results of Table IV and the limb darkening curve for the chromospheric background were employed. The results appear in Table III. The limb darkening curve of the flocculi appears in Figure 5; the limb darkening curve of the chromospheric background also appears in the same figure. Comparing the two curves we see that the limb darkening of the flocculi is less steep than that of the chromospheric background.

The curve of the Figure 6 was used for the reduction of the values of n for 2370 flocculi at the center of the disk. The distribution of their intensity is shown in Figure 7. The average value of n is 1.347 ± 0.003 and the standard deviation 0.163.

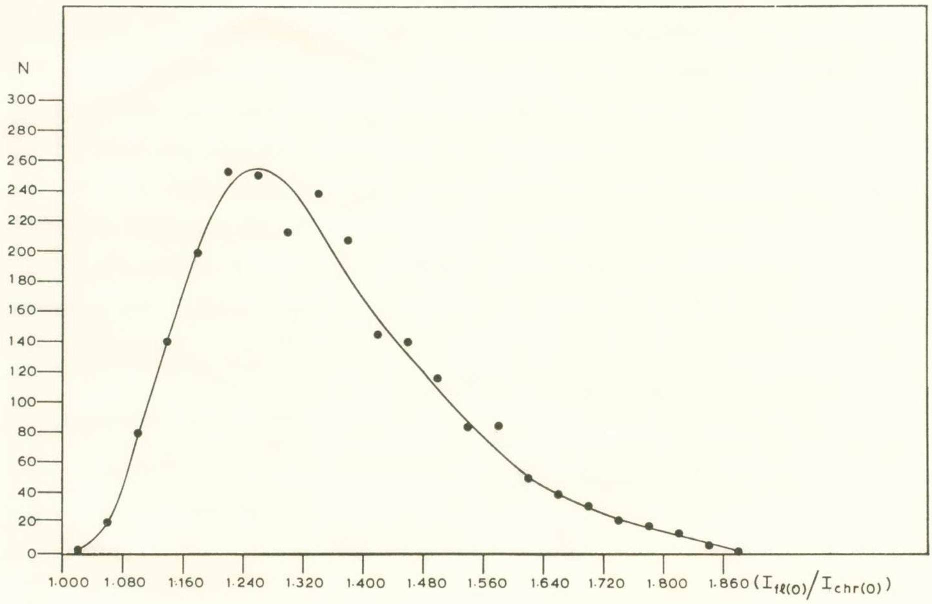

Fig. 7. Frequency distribution of the ratios $I_{fl(0)} / I_{chr(0)}$ of the 2370 measured flocculi.

B. THE REAL VALUE OF THE RATIO I_{fl} / I_{chr} REDUCED TO THE CENTER OF THE SOLAR DISK.

During the photometric measurements of the spectroheliograms the microphotometer does not record the maximum intensity of each flocculus, because the probability that the spot of the microphotometer passes through the brightest region of a flocculus is small. Of course some of the ratios I_{fl} / I_{chr} correspond to the maximum intensity values, but most of them correspond to lower ones. Therefore the calculated mean value of the ratio n = 1,347 is lower than the true one, which must be found.

At first, we made photometric tracings covering the whole area of a single flocculus and calculated for each tracing the ratio n. If ν is the number of the tracings we will obtain ν values of the ratio n. Since the successive tracings are obtained by the displacement of the spectrohelio-

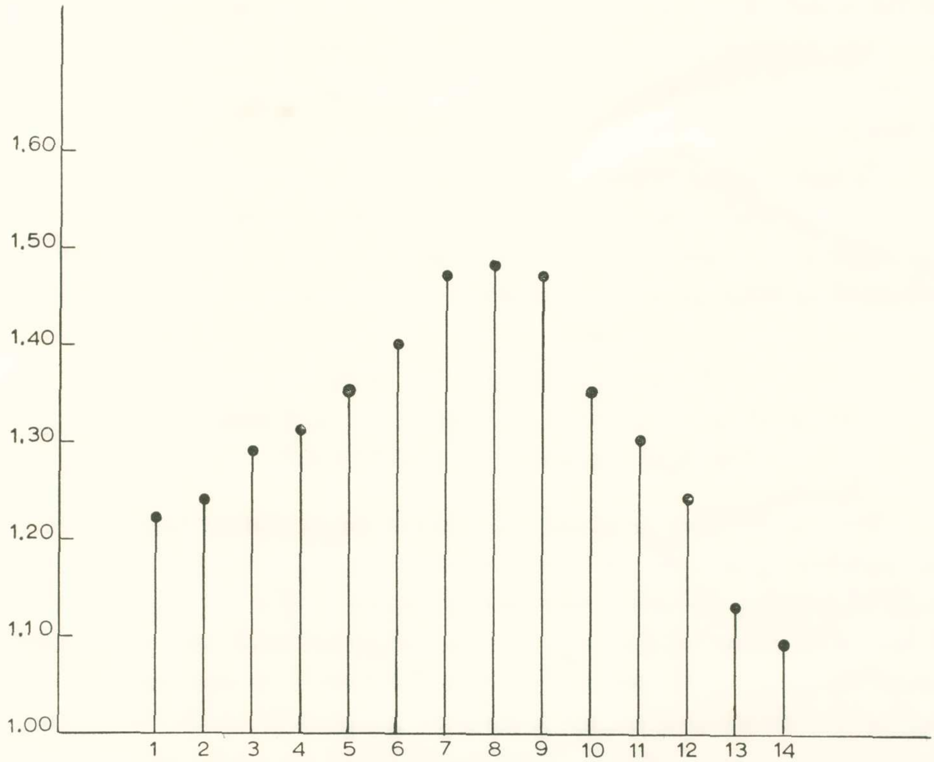

Fig. 8. Variation of the ratio I_{fl} / I_{chr} of a single flocculus obtained by 0.1 mm successive displacements of the microphotometric spot.

gram by spaces almost equal to the diameter of the spot, one of the above values of ν must correspond to the maximum intensity of the flocculus. The maximum value of the intensity was measured and the ratio $m = \frac{n_{max}}{\bar{n}}$, where $\bar{n}$ is the average value of the intensity, was calculated.

This ratio determines the coefficient by which we should multiply the mean value $\bar{n}$ to find the maximum value of the intensity of one flocculus.

To find the mean value of the coefficient m we worked on $K_{2,3}$ spectroheliograms and measured a region of flocculi at the center of the solar disk. This region was displaced by 0.1 mm each time so that the spot of the microphotometer would pass over the whole area of each of the flocculi in this area. Thus the successive tracings we obtained, gave us the veriation of the ratio I_{fl} / I_{chr} for each flocculus.

For example let us examine the case of one flocculus. The values of the ratio I_{fl} / I_{chr} which we obtained after measuring the whole area of this flocculus are given in Figure 8.

In the above example the mean value $\bar{n}$ of the ratios I_{fl} / I_{chr} is equal to 1.31 while the maximum value is 1.48. Therefore $m = 1.13$.

The mean value of m is 1.10. Using this value we found that the corrected intensity of the flocculi at the center of the disk is 1.482 ± 0.003.

5. DETERMINATION OF THE VALUES OF THE RATIO I_{fl} / I_{chr} FOR THE REGIONS NEAR THE HELIOGRAPHIC LATITUDES $\pm 53°$

For the calculation of I_{fl} / I_{chr} for the polar regions determined by the parallels $\pm 48° - 58°$, we used the spectroheliograms of Table I. The mode of working has been described in chapter 2. For the determination of the mean value of the ratio I_{fl} / I_{chr} we considered only the flocculi which are found in the hatched regions of Figure 2. At the centers of this regions the distance from the center of the disk is $\sin \vartheta = 0.8$. These regions were chosen because, in all the pictures we used, they contained only flocculi and not faculae.

We denote the north region by NR and the south ones by SR. In the NR and SR regions we measured the intensities and calculated the ratios I_{fl} / I_{chr} for 1055 and 1082 flocculi respectively. Then we corrected the values I_{fl} / I_{chr}, as described in section 3 and 4B. The final mean values are: $(I_{fl} / I_{chr})_{NR} = 1.467$, $(I_{fl} / I_{chr})_{SR} = 1.451$.

The flocculi of the hatched regions are not exactly at distance $\sin \vartheta = 0.8$ from the center of the disk. However the intensity chromospheric background varies with the distance and the values of I_{fl} / I_{chr}, and in consequence their mean value, may differ a little from the true one.

To find a better approximation of the real value we calculated the mean value of I_{fl} / I_{chr} only for 376 flocculi in the NR (Figure 2, region E) and 383 flocculi in the SR (Figure 2, region F), which were found very close to the center of the region, where $\sin\vartheta = 0.8$. The mean values are

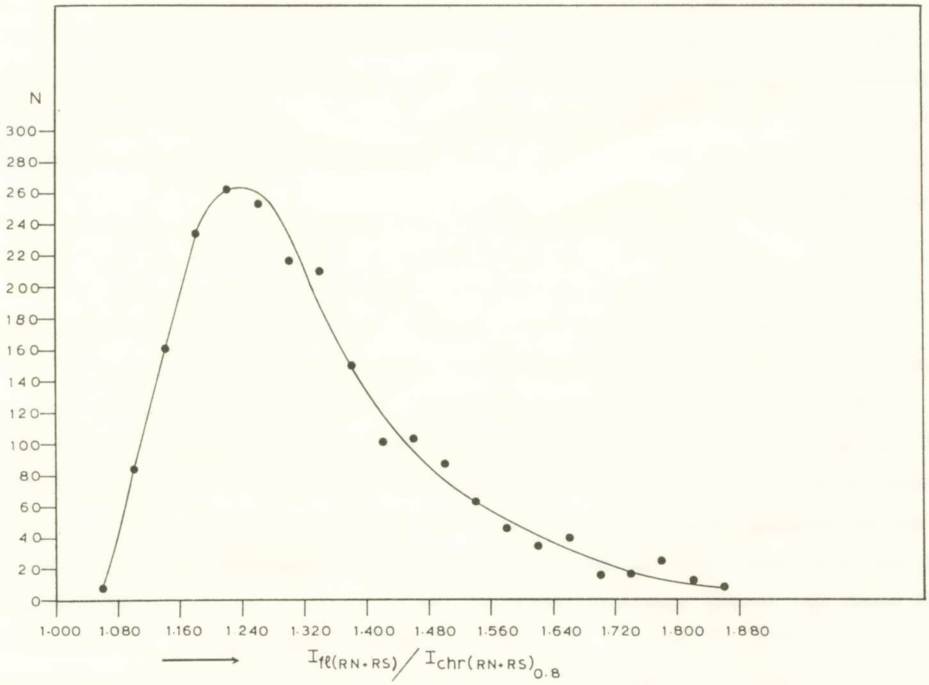

Fig. 9. Frequency distribution of the ratios $I_{fl(RN)} / I_{chr(RN)}$ and $I_{fl(RS)} / I_{chr(RS)}$ of the 2137 measured flocculi.

$(I_{lf} / I_{chr})_{NR} = 1.468$ and $(I_{fl} / I_{chr})_{SR} = 1.441$. If we compare these new mean values to the preceeding ones we see that they are almost the same. This is so, because the various distances of region E from the center of the disk do not differ much from the distance $\sin\vartheta = 0.8$. Thus for a radius of disk 31 mm, the maximum distance is $\sin\vartheta = 0.806$. The background intensity at this distance differs slightly from the central ($\sin\vartheta = 0.8$) one, and does not influence significantly the mean value of I_{fl} / I_{chr}.

Anyway as mean values we used the new ones, that is $(I_{fl} / I_{chr})_{NR} = 1.468$, $(I_{fl} / I_{chr})_{SR} = 1.441$.

The above values differ by 0.027. If we admit that there is no other reason for this difference we get a mean value of I_{fl} / I_{chr} for both polar regions, that is $I_{fl} / I_{chr} = 1.455$.

The distribution of the ratios I_{fl} / I_{chr} for both N and S regions (2137 flocculi) is shown in Figure 9.

This is the distribution of the values we found for the ratios I_{fl} / I_{chr} of the N and S regions, without the correction of section 4B. The correction 4B has been also omitted for the flocculi of the equatorial zone. The mean values of the ratios $(I_{fl} / I_{chr})_{RN}$ and $(I_{fl} / I_{chr})_{RS}$ without the correction 4B are respectively 1.334 and 1.319 (mean value of those two 1.327).

6. DISCUSSION

The mean value of the ratio I_{fl} / I_{chr} at the center of the solar disk was found to be, after the appropriate corrections, 1,482.

Besides the correction of the error due to the mechanical inertia of the microphotometric recorder and the necessary reduction of the value of the ratio I_{fl} / I_{chr} to the center of the solar disk because of the limb darkening effect, a correction was made to eliminate the error due to the scattered light in the spectroheliograph. For the latter correction we used the recent measurements of the K profiles made by White and Suemoto (1968). If we use Thakeray's (1935) measurements we find that the corrected mean value of the ratio I_{fl} / I_{chr} is equal to 1.375, that is 7% smaller than the one we found. This shows that this correction depends on the accurate measurements of the K profile.

Another possible error may result from the assumption that the effect of the scattered light on the flocculi and on the chromospheric background is the same.

The real value of the ratio I_{fl} / I_{chr} depends on the real value of I_{fl} which can be found by multiplying the mean value of the various intensities of one flocculus by a factor $m = 1.10$. This factor was determined from measurements of flocculi of all sizes at the center of the solar disk.

If we compare the values of the ratio I_{fl} / I_{chr}, which were measured at the equatorial and polar regions at distance $\sin\vartheta = 0.8$ from the center of the solar disk, we see that their difference is significant $[(I_{fl_{eq}} / I_{chr_{eq}})_{0.8} = 1.570$ and $(I_{fl_{Pol. Reg.}} / I_{chr_{Pol. Reg.}})_{0.8} = 1.455]$. However, we should find out whether this difference is due to a physical reason or to the error of the spectroheliograph.

The grating of the Arcetri spectroheliograph curves the line K of CaII, while the slit from which this line passes is straight. It is therefore possible that at distance $\sin\vartheta = 0.8$ from the center of the solar disk on the polar radii, the slit of the spectroheliograph includes besides $K_{2,3}$ another part of the K line, which might alter the intensity of the flocculi and background, and give an unreal value of I_{fl} / I_{chr}.

The influence of this curvature is being studied and the results will be given in a following paper.

If we prove that the curvature of the line has no influence on the intensities, then the difference of the above values has a physical reason, which we will try to find out.

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I also wish to thank Mr. C. Alissandrakis for reading the manuscript and offering some helpful comments and Mrs H. Dara for her valuable assistance on several points of the present work.

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ΠΕΡΙΛΗΨΙΣ

Εἰς τὴν παροῦσαν ἐργασίαν μελετῶνται φωτομετρικῶς τὰ μικρῶν διαστάσεων κέντρα ἐκπομπῆς τῆς ἡλιακῆς χρωμοσφαίρας, ἡ ὁποία παρατηρεῖται διὰ τῆς γραμμῆς $K_{2,3}$ τοῦ ἰονισμένου ἀσβεστίου. Τὰ μικρὰ ταῦτα κέντρα ἐκπομπῆς, καλούμενα νιφάδες, ἀποτελοῦν τὸ ὑλικὸν δομῆς τῆς χρωμοσφαίρας τοῦ Ἡλίου, ὁ δὲ σχηματι-

σμὸς αὐτῶν ἐντὸς τῆς ἡλιακῆς ἀτμοσφαίρας ὀφείλεται εἰς τοπικὰ μαγνητικὰ πεδία, τῶν ὁποίων ἡ ἔντασις κυμαίνεται μεταξὺ 1 - 10 Gauss.

Σκοπὸς τῆς ἐρεύνης ταύτης εἶναι ἡ μέτρησις τῆς ἐντάσεως τῶν νιφάδων ἐν συγκρίσει πρὸς τὴν ἔντασιν τοῦ χρωμοσφαιρικοῦ βάθους, ἡ εὕρεσις δηλαδὴ τοῦ λόγου I_{fl} / I_{chr}, εἰς τὸ κέντρον τοῦ ἡλιακοῦ δίσκου. Αἱ ἐκτελεσθεῖσαι μετρήσεις ἀναφέρονται εἰς νιφάδας, τῶν ὁποίων αἱ διάμετροι κυμαίνονται μεταξὺ 7 καὶ 45 δευτερολέπτων τόξου.

Ἡ φωτομετρικὴ ἐργασία ἐβασίσθη ἐπὶ φασματοηλιογραμμάτων τοῦ Ἀστεροσκοπείου τοῦ Arcetri. Ἐχρησιμοποιήθησαν 23 φωτογραφικαὶ πλάκες, αἱ ὁποῖαι ἐλήφθησαν ἀπὸ τοῦ ἔτους 1953 μέχρι τοῦ ἔτους 1959. Αἱ φωτογραφικαὶ πλάκες ἐφωτομετρήθησαν διὰ τοῦ αὐτογραφικοῦ μικροφωτομέτρου τοῦ Ἀστεροσκοπείου τοῦ Arcetri, ἐλήφθησαν δὲ ἀνὰ δέκα ἐγγραφήματα τόσον ἐπὶ τῆς ἰσημερινῆς ζώνης τοῦ ἡλιακοῦ δίσκου, ὅσον καὶ ἐπὶ ζωνῶν εὑρισκομένων εἰς ἡλιογραφικὰ πλάτη $\pm$ 53°.

Αἱ μετρήσεις τῶν ἐντάσεων τῶν νιφάδων ἐπὶ τῆς ἰσημερινῆς ζώνης τοῦ ἡλιακοῦ δίσκου, κατόπιν τῶν ἐπενεχθεισῶν διορθώσεων, ἠνήχθησαν εἰς τὸ κέντρον αὐτοῦ. Εὑρέθη οὕτως ὅτι ἡ μέση τιμὴ τοῦ λόγου I_{fl} / I_{chr} ἰσοῦται μὲ 1,482 $\pm$ 0.003.

Αἱ μετρήσεις τῶν ἐντάσεων τῶν νιφάδων πρὸς τὴν ἔντασιν τοῦ χρωμοσφαιρικοῦ βάθους ἐπὶ τῶν πολικῶν ἀκτίνων καὶ εἰς ἀπόστασιν $\sin\vartheta = 0{,}8$ ($\pm$ 53°) ἐκ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου ἔδωσαν τὰς ἀκολούθους τιμάς: α) διὰ τὴν βορείαν περιοχὴν $I_{fl} / I_{chr} = 1{,}468$, καὶ β) διὰ τὴν νοτίαν περιοχὴν $I_{fl} / I_{chr} = 1{,}441$. Ἡ τιμὴ I_{fl} / I_{chr} ἐπὶ τῆς ἰσημερινῆς περιοχῆς καὶ εἰς τὴν ἰδίαν ἀπὸ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου ἀπόστασιν, $\sin\vartheta = 0{,}8$, ἀνέρχεται εἰς 1,570.

Εἰς προσεχῆ ἐργασίαν θὰ ἐξετασθῇ ἐὰν ἡ ἀνωτέρω διαφορά, μεταξὺ περιοχῶν κειμένων πλησίον τῶν πόλων καὶ ἐπὶ τῆς ἰσημερινῆς τοιαύτης καὶ εἰς ἀπόστασιν $\sin\vartheta = 0{,}8$ ἐκ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου, ὀφείλεται εἰς σφάλμα τοῦ φασματοηλιογράφου ἢ ἀποτελεῖ φαινόμενον τῆς ἡλιακῆς χρωμοσφαίρας.

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Κατὰ τὴν ἀνακοίνωσιν τῆς ἐργασίας «Ἐπὶ τῆς φωτομετρίας τῶν νιφάδων τῆς χρωμοσφαίρας $K_{2,3}$ τοῦ Ἡλίου» ὁ Ἀκαδημαϊκὸς κ. **Ἰωάννης Ξανθάκης** εἶπε τὰ ἀκόλουθα:

Ἡ παροῦσα ἔρευνα στηρίζεται ἐπὶ τῶν φασματοηλιογραμμάτων τοῦ Ἀστεροσκοπείου τοῦ Arcetri τῆς Φλωρεντίας, ἐχρησιμοποιήθησαν δὲ ὑπὸ τοῦ κ. Μακρῆ εἴκοσι τρεῖς φωτογραφικαὶ πλάκες, αἳ ὁποῖαι ἐλήφθησαν εἰς τὸ ἐν λόγῳ Ἀστεροσκοπεῖον κατὰ τὸ χρονικὸν διάστημα 1953 - 1959.

Ἡ σχετικὴ ἔρευνα ἐπὶ τοῦ προκειμένου ἀναφέρεται εἰς τὴν μέτρησιν τῆς ἐντάσεως τῶν μικρῶν διαστάσεων κέντρων ἐκπομπῆς, ἅτινα καλοῦνται νιφάδες, ἐν σχέσει πρὸς τὴν ἔντασιν τοῦ χρωμοσφαιρικοῦ βάθους, τόσον ἐπὶ τοῦ ἰσημερινοῦ τοῦ Ἡλίου, ὅσον καὶ ἐπὶ ζωνῶν εὑρισκομένων εἰς ἡλιογραφικὰ πλάτη $\pm$ 53°.

Διὰ τῶν ἐν λόγῳ μετρήσεων, ἐπὶ τῶν ὁποίων ἐφηρμόσθησαν ὅλαι αἱ ἀναγκαῖαι διορθώσεις, ἀναγωγαὶ καὶ ὑπολογισμοί, ὁ κ. Μακρῆς συνάγει τὴν μέσην ἔντασιν τῶν νιφάδων πρὸς τὴν ἔντασιν τοῦ χρωμοσφαιρικοῦ βάθους εἰς τὸ κέντρον τοῦ ἡλιακοῦ δίσκου, εὑρίσκει δὲ τὴν τιμὴν 1,482 $\pm$ 0,003.

Αἱ μετρήσεις τῶν ἐντάσεων τῶν νιφάδων ἐπὶ τῶν πολικῶν ἀκτίνων καὶ εἰς ἡλιογραφικὸν πλάτος $\pm$ 53°, περιοχὴν ἡ ὁποία ἀπέχει ἐκ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου κατὰ 0,8 τῆς ἀκτῖνος αὐτοῦ, ἔδωσαν τιμὰς αἱ ὁποῖαι διαφέρουν ἀπὸ ἐκείνας αἱ ὁποῖαι εὑρέθησαν ἐπὶ τῆς ἰσημερινῆς ἀκτῖνος καὶ εἰς τὴν ἰδίαν ἀπὸ τοῦ κέντρου τοῦ ἡλιακοῦ δίσκου ἀπόστασιν.

Ἡ διαφορὰ αὕτη εἶναι δυνατὸν νὰ προκαλῆται ἀπὸ αἰτίαν ἡ ὁποία ἔχει τὴν ἕδραν της ἐπὶ τῆς ἡλιακῆς χρωμοσφαίρας, εἶναι ὅμως δυνατὸν νὰ ὀφείλεται καὶ εἰς σφάλμα τοῦ χρησιμοποιηθέντος φασματοηλιογράφου, διὰ τοῦ ὁποίου ἐλήφθησαν αἱ φωτογραφίαι.