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THE CENTER-TO-LIMB VARIATIONS OF SOME SOLAR SPECTRAL LINE PARAMETERS

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Summary: The statistical analyse of center-to-limb changes in equivalent widths and coefficients of asymmetry and excess of 83 Fraunhofer lines was done.

1. INTRODUCTION

On a low accuracy level solar photospheric spectral lines can be considered to have the gaussian profile because the most important source of line broadening is the thermal and microturbulent velocities, but high-resolution spectra reveal a non-gaussian line profile. This slight deviation from the gaussian profile may be produced by many different physical conditions in solar photosphere. For instance the asymmetries of the line profile can be traced back to photospheric temperature and velocity field inhomogenities.

To consider quantitatively the deviation of the spectral line profile from gaussian one we used a statistical analysis by introducing the coefficients of asymmetry and excess of intensity distribution function of the line profile. Beside we calculated the equivalent widths too.

2. SPECTRAL DATA AND REDUCTIONS

In this paper we analyzed 84 spectral lines of neutral elements for 5 positions ($\cos\theta$ = 1, 0.8, 0.6, 0.436, 0.28) at the solar disk published by Gurtovenko at all. (1975). For all line profiles at each position we calculated equivalent width:

$$W = \sum_{i=1}^{n} x_i y_i \qquad (1),$$

where x_i is the difference between central and measured wavelength, and y_i is the corresponding intensity.
Coefficients of asymmetry we calculated from:

$$As = \frac{\sum_{i=1}^{n} x_i^3 y_i}{\sigma^3} , \qquad (2)$$

σ is dispersion, and coefficient of line excess from

$$Ex = \frac{\sum_{i=1}^{n} x_i^4 y_i}{\sigma^4} - 3 . \qquad (3)$$

We classified the line profiles according to excitation potential of lower energy level (χ_e) and to equivalent widths into different groups. Number of lines in each group are shown in Table 1.

Table 1 :Number of lines in each group used for the present analysis

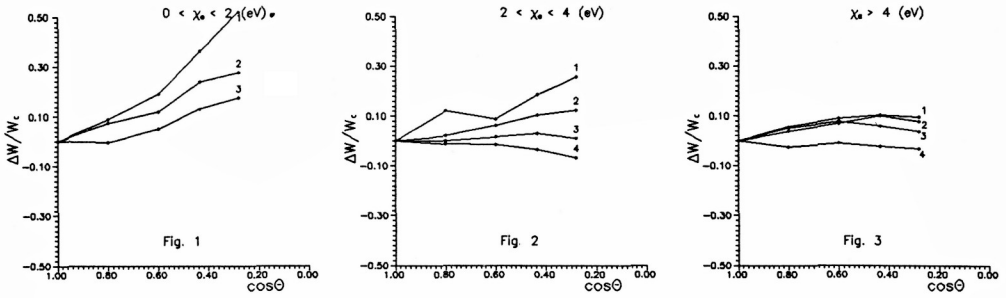
N	χ_e (eV)		
W (mA)	0 - 2	2 - 4	> 4
0 - 10	15	3	11
10 - 25	5	1	13
25 - 50	3	8	3
50 - 100	1	11	5
>100	0	4	0

As one can see, there are two groups with only one line. Those groups are linked with groups with lower equivalent widths.
For all groups we calculated mean relative changes of equivalent widths and mean changes of coefficient of asymmetry and coefficient of excess. The results are presented in Figures 1-9.

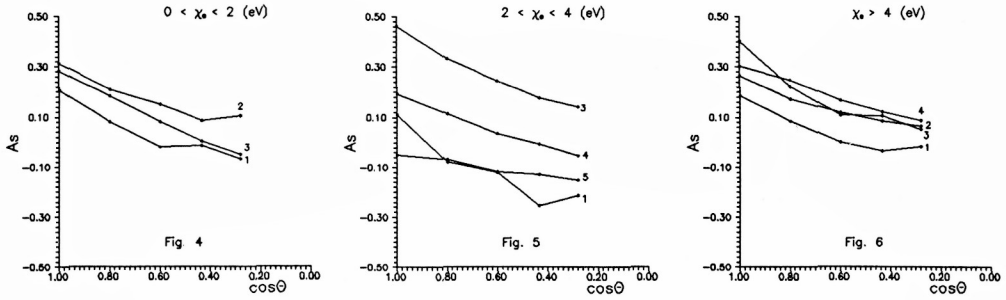
3. DISCUSSION

a) Equivalent width

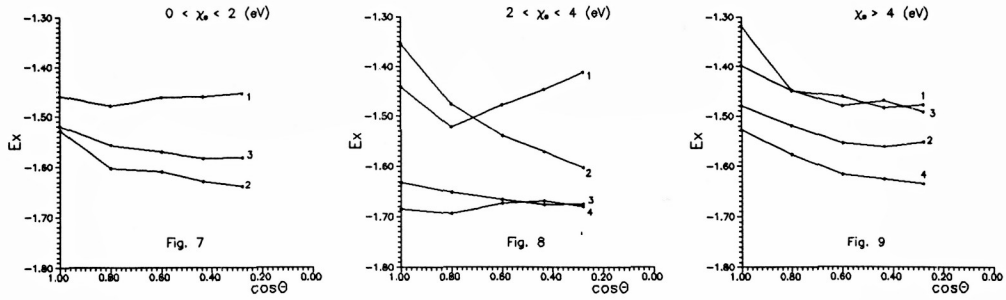
From Figures 1-3 one can see center-to-limb relative changes of equivalent widths of selected spectral lines.
Relative changes in equivalent widths are large for lines with lower χ_e , and lower equivalent width. Those results we can interpret with fact that effective temperature of photosphere decrease from center to limb of solar disk, and this lines are formed in thinner layers.
Changes of spectral lines with high χ_e are near zero and in some cases are negative. Possible reason for this is that those lines are less sensitive on temperature changes because they are formed almost in whole photosphere.
It is interesting that lines with the highest χ_e and the largest equivalent widths have small but negative changes.



Figs. 1-3: Center-to-limb relative changes of equivalent widths for different χ_e (In Fig.1: 1 - 0 < W < 10, 2 - 10 < W< 25, 3 - 25 < W < 50; Fig.2: 1 - 0 < W < 25, 2 - 25 < W < 50 3 - 50 < W < 100, 4 - W > 100; Fig.3: same as Fig.1 and 4 - W > 50)



Figs. 4-6: Center-to-limb changes of coefficient of asymmetry for different χ_e (Labels are same as in Figs.1-3 respectivelly.)



Figs. 7-9: Center-to-limb changes of coefficient of excess for different χ_e (Labels are same as in Figs.1-3 respectivelly.)

b) Line asymmetry

Figures 4-6 show center-to-limb variations of the coefficient of asymmetry.
We can see that there is a decrease in line asymmetries.
At the center of the Solar disk all mean coefficients of asymmetry are positive except of lines with equivalent widths larger than 0.1. When we are going to the limb of the solar disk, the coefficient of asymmetry of some lines changes a sign.
Possible explanation of those facts is in the pressure change or in the change in hydrodynamical parameters across the line formation layers.
A different contribution of granular and intergranular space seen by the instrument may introduce some errors as has been shown by Marmolino and Severino (1981).

c) Line excess

Center-to-limb variations of the line mean coefficients of excess are shown in Figures 7-9. All mean coefficients are between -1.3 and -1.7. Interpretation of that fact needs more analyses, but we think that possible solutions are in influence of different pressure broadening and large scale motions in solar photosphere.

4. CONCLUSION

In conclusion we can state that some general trends in Solar spectral line widths and coefficient of asymmetry and excess are found. Detail explanations of those trends needs further research.

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