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STUDY OF SPECTRAL LINE ASYMMETRY IN SUNSPOTS

LUDMÁNY A.

Abstract: *The previously found inverse line asymmetry is studied in sunspots near to the solar disc center.*

ИССЛЕДОВАНИЕ АСИММЕТРИИ СПЕКТРАЛЬНОЙ ЛИНИИ В СОЛНЕЧНЫХ ПЯТНАХ

ЛУДМАНЬ А.

Абстракт: *Исследуется раньше найденная инверсия асимметрии линии в солнечных пятнах вблизи центра солнечного диска.*

SPEKTRUMVONAL-ASZIMMETRIA VIZSGÁLATA NAPFOLTOKBAN

LUDMÁNY ANDRÁS

Összefoglalás: *Megvizsgáljuk a napkorong centrumához közeli napfoltok korábban talált negatív színképvonal-aszimmetriáját.*

INTRODUCTION

In a previous paper (Ludmány,1983, hereafter referred to as Paper I.) some observational facts have been published about the inversion of spectral line asymmetry in the majority of sunspots. The absence of the so-called "limb-effect" in sunspots (Beckers,1977) is in accordance with the theoretical assumptions about the inhibition of convection in magnetic fields - at least in the photospheric sense. However some other types of motion fields may exist in umbrae too, and the type of asymmetry of a spectral line may be an important characteristics of the motion, especially of inhomogeneities of velocity and intensity distributions, even without any shift of the line as a whole.

The present paper gives account of the investigation of the same problem on a more extended material, and in a somewhat more quantitative manner.

OBSERVATIONS AND THEIR REDUCTION

The most advantageous line for this purpose is the λ5714 Ti I , because it is magnetically insensitive,free of blends, and it has a favourable property: it is extremely weak in the quiet photosphere and fairly strengthened in umbrae, and so, the always problematic straylight has no influence to make systematic error, any tendency of photospheric origin cannot distort the result.

The observational material was of the same type as in Paper I. The photographic spectra were taken at the Main Astronomical Observatory of the Academy of Sciences of the Ukrainian SSR, in Kiev, Goloseevo. The instrument was the ACU-5 horizontal telescope, making a 16 cm diameter solar image on the 50 micron spectrograph slit. ORWO WO-3, and WP-3 plates were used with 2-24 sec exposure times. The position and size of the observed sunspots have been determined on the basis of the observational material of the Heliophysical Observatory of the Hungarian Academy of Sciences, Debrecen, which means the photospheric patrol observations with solar image of 11 cm diameter.

The spectrograph slit always crossed the center of the umbrae and the photospheric scanning was made with a slit height corresponding to 1", and by steps of 4.38 and 2.47 mÅ in the IV. and V. order respectively. The data were calibrated photometrically.

The most important action during the evaluations was the correction for the instrumental profile. It is quite obvious, that an asymmetrical transmission function (Fig. 1.) results an asymmetrical spectral line.

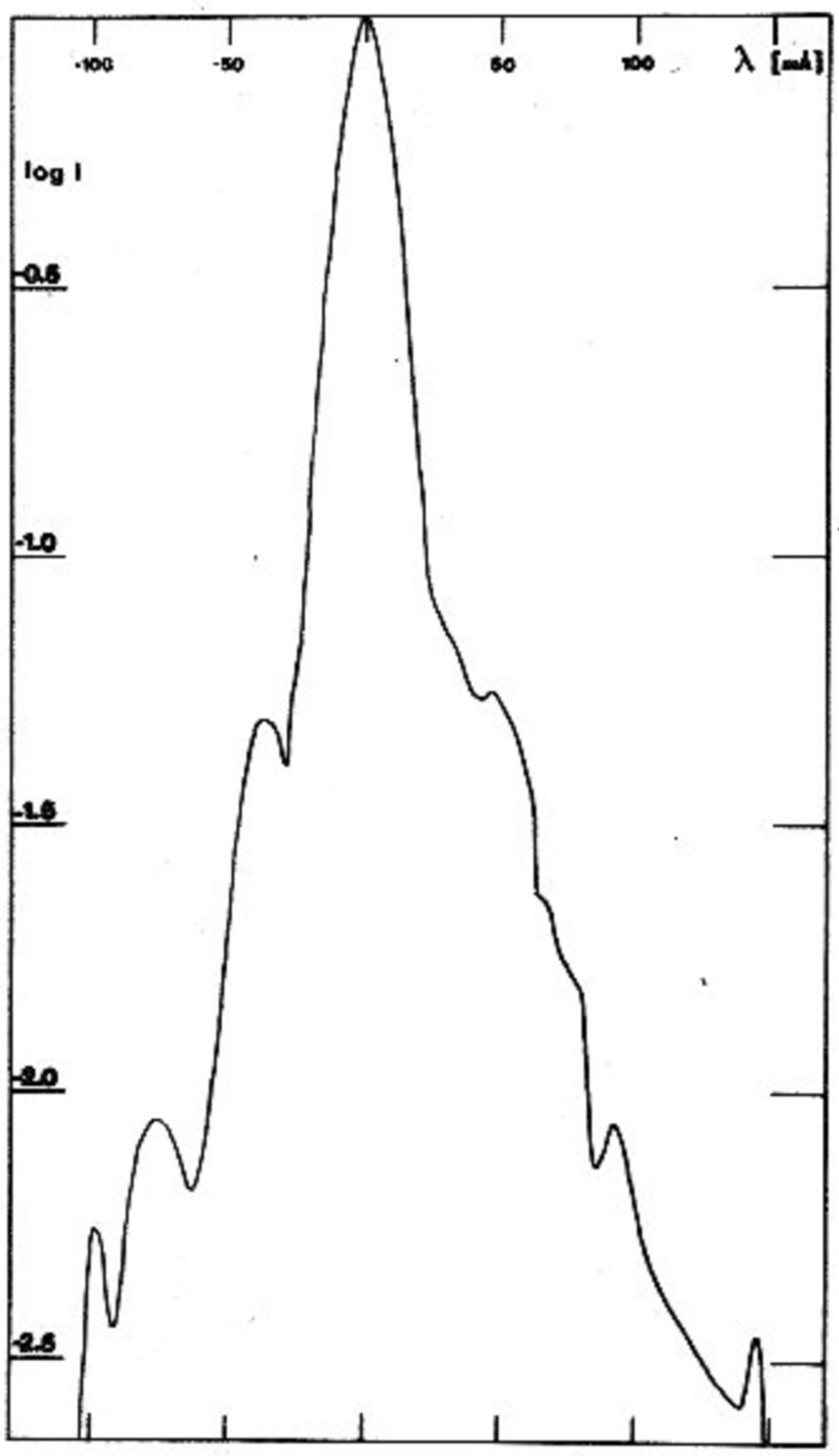

Fig.1. Instrumental profile of the ACU-5 teleskope (Kiev) in the fourth order.

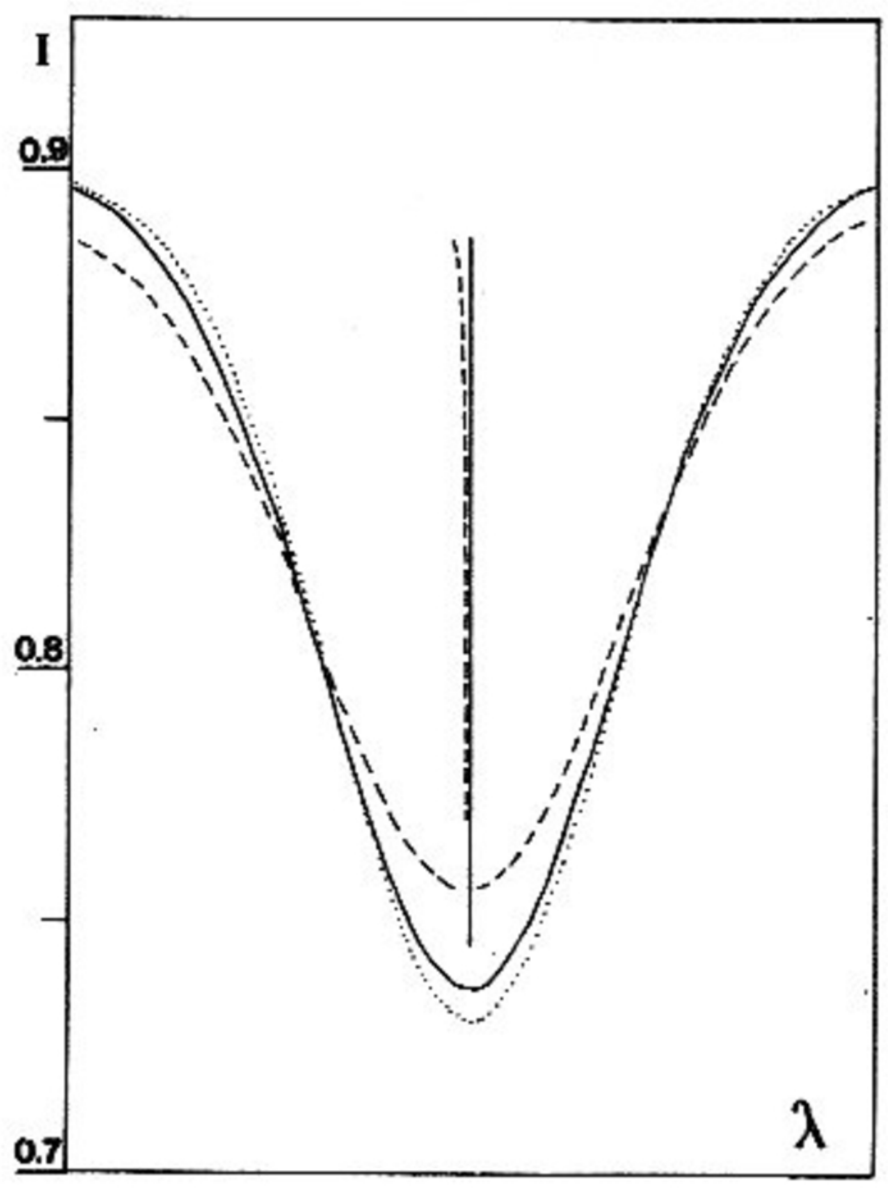

Fig.2. Gauss-profile (dotted line), resulting profile, after passage through the spectrograph (broken line), corrected profile (continuous line), the two latter with their bisectors.

To demonstrate this, an ideal Gauss-function was chosen as an entering line profile, and its convolution with the known instrumental profile was computed. The resulting curve with its bisector is plotted in Fig. 2. for the fourth order of the spectrograph. The distortion of the bisector is fairly remarkable, its upper part slightly declines to the left. In order to correct for this phenomenon, the deconvolution procedure described by Gurtovenko (1966) was carried out. This is an iteration method, and experience shows, that the first iterational step gives acceptable result, at least, as for the asymmetry, as is displayed in Fig. 2.

The most popular tool for the examination of asymmetry is the above mentioned bisector method. However, this is, after all, a slightly subjectiv indicator, and therfore some attempts are known to make it more quantitative. One of them uses the following formulae (Kostyk et al.,1976):

$$\Delta = \frac{\mu_3}{\mu_2^{\frac{3}{2}}}$$

$$\mu_i = \int (\lambda - \lambda_i)[1 - r(\lambda)]\, d\lambda$$

$$\lambda_c = \frac{\int \lambda [1 - r(\lambda)]\, d\lambda}{\int [1 - r(\lambda)]\, d\lambda}$$

Here μ_i is the i-th central momentum, λ_c is the position of the line center, and Δ is the measure of asymmetry.

OBSERVATIONAL RESULTS

The sunspot observations taken in the $\Delta\Theta<30^o$ $(\cos\Theta>0.87)$ surrounding of the solar disc centre were collected. After photometry some profiles obviously suffering from any defects were omitted. For the photometric calibration the photoelectric sunspot spectrum of Wöhl et al.(1970) was used.

The resulting material consists of 44 profiles. The whole material seems to show the same property, as that of the Paper I, namely a clear tendency to have an inverse asymmetry, although there are some positively asymmetric and any undefined examples. Instead of plotting all of the profiles, let the Fig. 3. show the above defined Δ asymmetry plotted versus sunspot area.

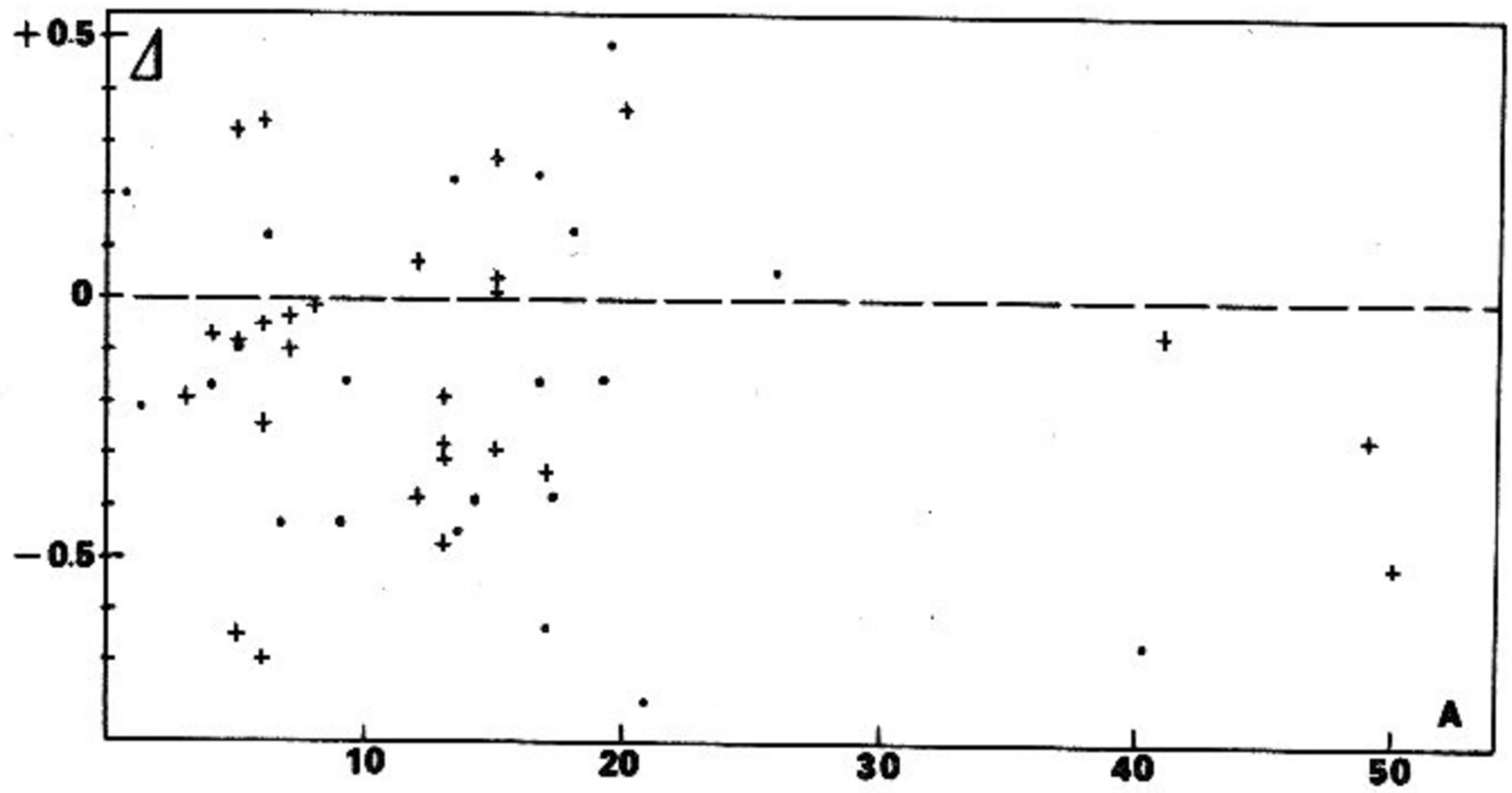

Fig.3. Asymmetry of the Ti I 5714Å line in sunspots versus sunspot area.

Crosses mark the data measured for the present work, and those of the Paper I (reduced to sunspots with $\Theta \leq 30^{\circ}$) are shown by dots.

The important feature of this figure is, that the distributions of the two materials (of Paper I and the present one) are rather near to each other, the distributions of the negative-positive declinations are: 12-5 in Paper I, 20-7 in the later evaluated material, and so, 73% of all profiles have negative asymmetries. From the point of view of interpretation it is not less important, that not all bisectors decline to the left. As for the area dependence it does not seem to have any clear tendency as was the case in Paper I too.

This line has been already applied by Beckers for line shift measurements (Beckers, 1977) and turbulence determination (Beckers, 1976) in sunspots. In this latter paper two concrete line profiles are published, one of them is that of the λ5714 Ti I line. Closer inspection of these figures reveals that both of these profiles have negative asymmetry, so it appears, that the fact of asymmetry exists, and it should be accounted for.

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