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ASYMMETRY OF NON-SPLITTING SPECTRAL LINES IN SUNSPOTS

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Abstract:

Instead of the usual C-shape of the photospheric line asymmetries, an opposite tendency seems to be present in sunspot umbrae for the λ5713.896 TiI line in most cases.

АСИММЕТРИЯ НЕРАСЩЕПЛЕННЫХ СПЕКТРАЛЬНЫХ ЛИНИЙ В СОЛНЕЧНЫХ ПЯТНАХ

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Абстракт:

Вместо обычной С-формы асимметрии фраунгоферовых линий невозмущенной фотосферы, кажется, обратная тенденция поступает в тенях солнечных пятен в линии λ5713.896 TiI в большинстве случаев.

Introduction

As is widely accepted, in sunspots the convective motions are inhibited, or at least essentially altered. So such manifestation of the convection as the limb-effect is proven to be absent in sunspots on the basis of Abbe-comparator measurements made by Beckers {1}. But the convective motion field has another effect in the undisturbed photosphere: the well known *C*-shape of the bisector of the asymmetric lines, see e.g. Dravins {2}. On the other hand, the umbral dots have a granulation-like pattern. Obridko {3} has given more arguments in favour of the two-component model of sunspot umbrae, similar to Schröter's "Zweistrom-Modell" of the limb-effect {4}. So, the study of line-asymmetry, which is a sensible indicator of intensity- and velocity inhomogeneities, may be of importance in umbrae too.

Observations

The asymmetry of a line can be used for velocity field investigations in sunspots only if there are no disturbing circumstances, such as blending or magnetic splitting. The most complete list of g=0 lines is given in {5}. So far, mainly the well known λ5576.099 FeI line has been used for this purpose, see e.g. {6}, {7}, {8}, but it is not very suitable because it is blended in sunspot umbrae. The most suitable line for asymmetry measurements in sunspots is the λ5713.896 TiI. Its main advantages are: g=0, no blend, W=5mÅ in the undisturbed photosphere and considerable strengthening in sunspots. This last point is rather useful, because if there were an asymmetrical line present in the surrounding photosphere, the occasional different photospheric asymmetry could disturb the measurements in the umbrae on account of scattered light.

The observational material has been collected in the Main Astronomical Observatory of the USSR Academy of Sciences in Kiev with the ACU-5 horizontal telescope. I used the spectrograph in the fourth and (later) fifth order (dispersion 2.28 and 4.02 mm/Å respectively). The photographic material was ORWO WO-3 or WP-3, width of spectrograph slit 50 micron, exposures ranging from 2 sec to 24 sec depending on the circumstances.

During the observations special care was taken to ensure that the slit was always across the center of the umbrae. During the photometric evaluation a slit height corresponding to 1" was chosen. After photometric calibration the instrumental profile was taken into account.

Presumably the asymmetry, if it exists at all, depends on the size and position (θ) of the spot, they have been determined on the basis of the observational material of the Debrecen Heliophysical Observatory.

Discussion

Fig.1 shows the view of two spots, and the size of one millionth of the solar hemisphere (mh) and the corresponding registrated titan line profile with the bisector, the wave-

length scale is centered on the line bottom. These two spots were just on the center of the solar disc at the moment of observation. In Fig.2 the measured bisectors are plotted in different groups according to the size of the spot ($\cos\theta>0.9$). The first group contains little spots, (A<8 mh), the second contains medium size spots, (8 mh<A<15 mh) and the third contains large spots (A>15 mh). Spots with different θ are shown in Fig.3 independently of their sizes.

It is remarkable that there is a tendency for an asymmetry opposite to that of the photospheric *C*-shape to develop almost independently of the size of the spot considered. This suggests that the umbral dots could be the reason for line asymmetry. It is shown by model computations that in granular patterns differing from the solar photospheric one, the sense of asymmetry of lines may be opposite to that of the solar photospheric ones, if little bright elements and larger dark intergranular lanes are present {2}. According to the available information on umbral dots {9}, they do have a geometry like this. The variability may be caused by the fact that in the relatively small sunspots a slight change in the bright dots may considerably alter the asymmetry, unlike the quiet photosphere where larger, averaged areas are always considered.

I would like to express my gratitude to the members of the Kiev Institute for their assistance and I am particularly indebted to E.A. Gurtovenko for his encouragement and help, and to S.I. Gandzha for taking the instrumental profile into account.

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An additional note

During the discussions following the presentation of the above study, V.N. Obridko mentioned that Makita reported similar results to him (to be published) concerning the inversion of asymmetry in sunspots.

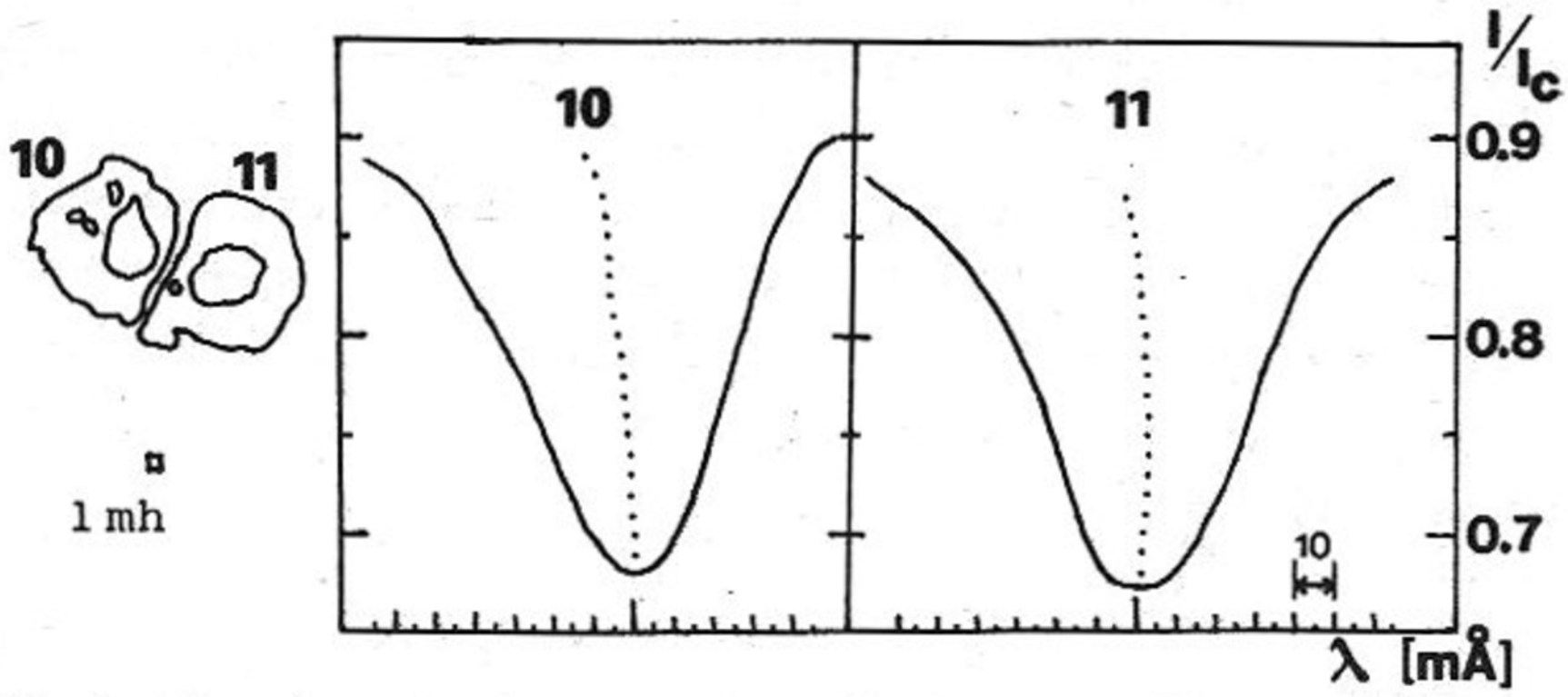

Fig.1. The view of two sunspots with the titan line profiles with bisectors registrated in the spots.

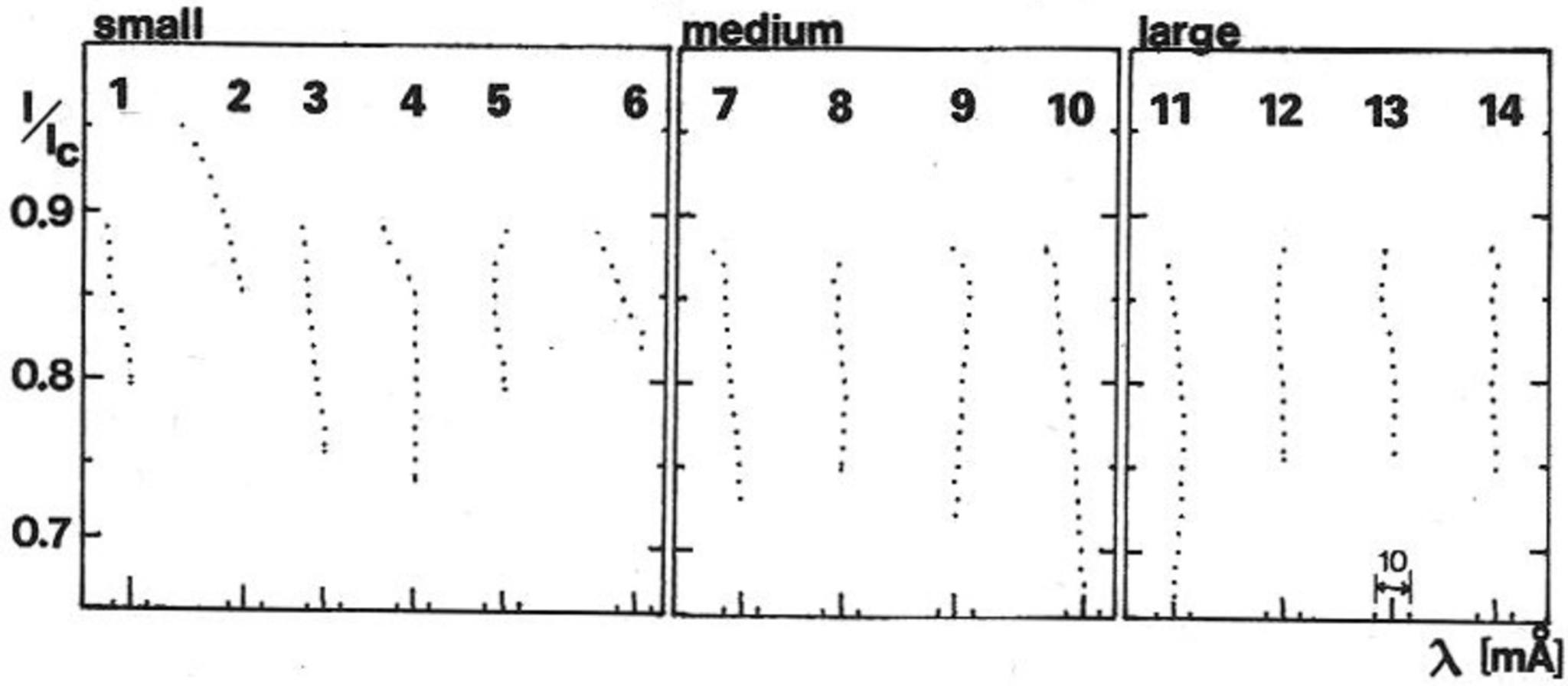

Fig.2. Bisectors of the Ti line registrated in sunspots of different sizes close to the center of the solar disc.

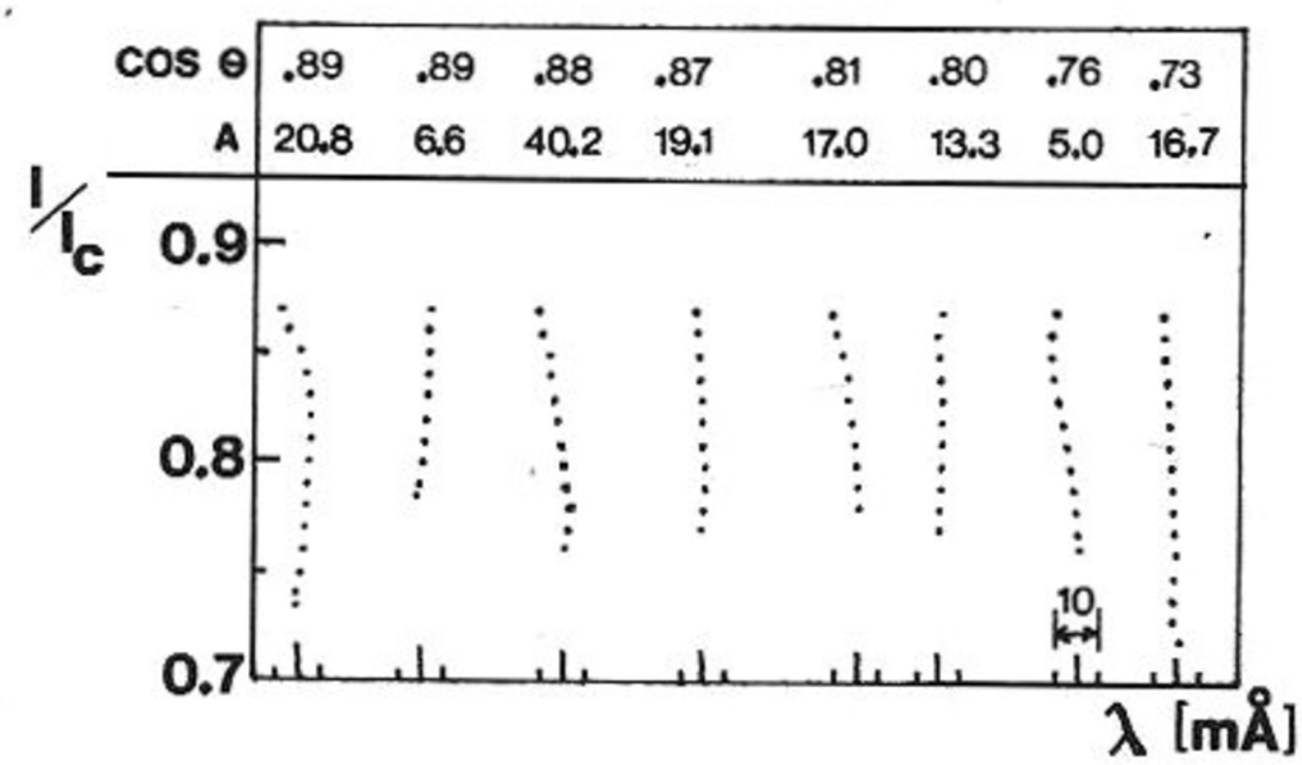

Fig.3. Bisectors of the Ti line registrated in sunspots of different sizes at different position angles.

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