EQUATOR-POLE EFFECT IN THE CENTRAL INTENSITIES OF SOME STRONG SOLAR FRAUNHOFER LINES

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Abstract. Uncorrected central intensities of the Fraunhofer lines NaD1 and D2, Mgλ1 and b2, and Hβ have been determined at a number of points along the S–W limb of the sun, from equator to pole, using photographic spectra taken at the Locarno station of the Göttingen Observatory. No significant pole-equator variation could be found in excess of the observational errors which are of the order of 2%.

1. Introduction

In 1964, during a period of low solar activity, a program was carried out to make observations of Fraunhofer line profiles for the quiet sun. One of the aims of the investigation was to determine true line profiles by using spectrographs of high resolving power for which the photometric corrections are known. The centre-to-limb variation of different lines was also investigated. Another aspect was to compare line profiles, determined with different methods at different observatories. Observations have been made at the solar research institute of the Göttingen Observatory, situated in Orselina near Locarno, at the Jungfraujoch, at Kitt Peak and at Utrecht.

Special interest was given to the equator to pole effect which has been investigated by several authors (Abetti and Castelli (1935), Allen (1949), Das and Abhyankar (1953), Bishop (1956), Beckers (1960, 1962), Mulders and Slaughter (1965) and Appenzeller and Schröter (1967)), with somewhat questionable results.

In this publication some preliminary results from the Locarno observations are given about the equator to pole variations of uncorrected central intensities of the Fraunhofer lines NaD1 and D2, the Mgλ1 and b2 lines and Hβ.

2. Observations

The observations were made by J. Houtgast in July 1964. The spectrograph has been described by ten Bruggencate and Voigt (1958) and by Brückner (1964). Use was made of the echelle grating in the 10th to 14th orders with a dispersion of about 10 mm/Å. According to Wiehr (1965):

(1) the instrumental profile is well known and has a total halfwidth of 11.5 mÅ at λ 4358 Å in the 14th order

(2) the intensities of ghosts are as follows:

<table>
<thead>
<tr>
<th>wavelength region</th>
<th>1st ghost</th>
<th>2nd ghost</th>
<th>spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>λ 4358 Å in 13th order</td>
<td>$4 \times 10^{-4}$</td>
<td>$1 \times 10^{-4}$</td>
<td>4.1 Å</td>
</tr>
<tr>
<td>λ 5461 Å in 11th order</td>
<td>$1.5 \times 10^{-4}$</td>
<td>–</td>
<td>6.25 Å</td>
</tr>
</tbody>
</table>

(3) concerning the scattered light the following is known: in a monochromator transmission region containing 60 Å of the solar spectrum including the NaD lines central intensities for the D lines are found, which are 4.2% higher than those of Waddell (1962); Wiehr's measurements give a background of $5 \times 10^{-5}$ between the 1st and 2nd ghost of Hg 4358 Å.

Our spectra were photographed on Agfa Isopan F plates. The observations consist of spectra at $\sin \vartheta = 0.00$ (centre sun), 0.955, 0.98 and 0.99 with a tangential slit and from 0.95 up to over the sun's limb with a radial slit. Each region on the sun was taken with two different exposure times.

The centre was taken through a weak gray NG 5b/1 filter. Thus 10 exposures were taken on each plate along one solar radius.

The orientation of the solar image on the fixed slit was obtained by means of a rotatable Dove prism placed just before the slit. It was verified that the rotation of the Dove prism did not change the illumination of the grating. The slit width was made equal to $\lambda F/a$ in which $a/F$ is the angular aperture of the spectrograph.

The Dove prism proved especially useful for the orientation of the solar image for exposures along different radii. Most series began at the southern limb and went towards the western limb by steps of 15°. A correction was made to the nominal position angles to allow for the rotation of the solar image with hour angle, and the orientation of the sun's axis towards N–S was taken into account. A complete series of observations in one spectral region contained spectra along 9 or 10 solar radii. A whole series took about 1½ hours observation time, and most series were complete.

The position of the slit with respect to the sun's limb could be determined by looking at the reflecting slit jaws through a small telescope with micrometer. Since the diameter of the sun's image was 23.6 cm, $\sin \vartheta = 0.99$ was at a distance of 1.18 mm from the limb. This distance was always much greater than the unsharpness and the movement of the sun's edge. The first slit is slightly curved in order to obtain straight spectral lines in the spectrum; with the slit in the tangential position we choose the most favourable setting.

Separate calibration plates were taken with a G 11 photometer from Zeiss, Jena.

3. Analysis

The spectra were traced with a microphotometer in Utrecht. The characteristic curves per series did not show any systematic variation with the exposure time. Because of the good agreement between the straight parts of the various curves we used a mean characteristic curve to convert the recorded transmissions into intensities. To eliminate as much as possible the uncertainty caused by the flatter parts of the curve we always combined two spectra of different exposure times. In this way we were able to use exclusively the most accurate part of the characteristic curve for our determinations.

The wavelength region photographed around H$\beta$ was too short to enable us to draw the continuum. We selected the levels at 4850.5 Å and at 4868.7 Å which have