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LONGITUDINAL ASYMMETRIES OF THE CORONAL LINE INTENSITIES

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ABSTRACT

The analysis of the daily measurements of the coronal green line intensity which have been collected by the Pic-du-Midi Observatory during the period 1944-1974 has directed to some very interesting results. The main finding of this analysis is a permanent longitudinal asymmetry of the green line intensity which has been determined all along the data record. In our effort to make this asymmetry certain we have examined E-W intensity differences very close to the solar equator where the rotation rate for coronal features is equal to 25.35 days on the average. When we examine these data every 25 days, namely data which almost correspond to the same points of the solar disk, we confirm the above mentioned longitudinal asymmetry.

INTRODUCTION

The first report on a possible East-West (E-W) asymmetry of the green coronal line intensity had been made by Trellis since 1959. In a short article where Trellis had treated observations collected by the Pic-du-Midi coronagraph he had underlined the possibility that the East Solar limb appears more intense than the West.

In a rather recent paper Tritakis et al. (1988) analysing the Pic-du-Midi coronagraphic data again have revealed a significant E-W asymmetry of the green line intensity which extends within the whole data record namely from 1944 to 1974. In the present report we attempt to make the E-W phenomenon more evident as well as to point out that this effect is a real one free from observational or instrumental errors.

DATA ANALYSIS AND PROCESSING

The data we use in the present analysis are daily measurements of the absolute intensity of the coronal emission lines 5303 A° and 6374 A° collected by the Pic-du-Midi observatory for the period 1944-1974. This data set has been obtained in a polar coordinate system, defined by the central meridian passage and the solar equator. Seventy-two intensity values taken every 50 deg around the solar disk are obtained every day at a distance which varies from 2" to 40" from the solar limb.

In the present case we are interested in comparing certain points on the East and West solar limb for the entire data record 1944-1974. For this reason we have analysed our data under the following limitations and assumptions:

1.- We analyze data that have been obtained within a narrow zone 5° wide on both sides of the solar equator.
2.- In general the differential rotation of solar coronal features is given by the empirical relation:

$$\Omega = 14.24 - 0.4 \sin^2\varphi \text{ (deg/day)}$$

Where φ the heliographic latitude. From this equation the synodic rotation of a narrow zone ±5° wide on both sides of the solar equator where we analyse our data can be estimated to be $T \approx 25.28$ days.

Consequently, the data obtained within the above mentioned equatorial zone every 25 days or one solar rotation, correspond approximately to the same areas of the solar corona.

3.- In order to counterbalance a slippage of 0.28 days per solar rotation which arises from the difference between the estimated (25.28 days) and the approximate (25 days) rotational rate of the equatorial zone every 3-4 solar rotations we subtract one day from the current rotation day.

Under this point of view, all our data record can be separated in twenty five time series which start the first 25 days of our record respectively. Each one of these time series contains data separated by a time lag of 25 days that is, the data correspond approximately to the same area of the solar corona on the equator.

4.- We assume that in each day of a certain time series the asymmetry of the intensity between the East and the West solar limb is defined by the relation:

$$A = I_{\alpha} - I_{\omega} / I_{\alpha} + I_{\omega}$$

Where I_{α}, I_{ω} are daily values of the coronal green or red line intensity on the East and the West edge of the solar equatorial zone 5° wide on both sides of the equator.

EVIDENCE OF E-W ASYMMETRY OF THE GREEN AND RED LINE INTENSITY

In the figure 1, the asymmetry coefficient of the green line intensity variation of three time series which start on the 6^{th} day from the beginning of the data set and correspond to 45° North and South heliolatitude (upper and lower panel respectively) and the solar equator (intermediate panel), are depicted. These time series have been processed in the way we described in the previous section that is, they contain measurements collected with a time lag of 25 days. It is very clear that positive coefficients predominate in two of the three panels of figure 1, fact which implies that the East solar limb in the above mentioned heliolatitudes appear brighter than the West in most of the cases under consideration. This phenomenon is very clear at the solar equator (intermediate panel), quite clear on the 45° South but not obvious on the 45° North.

In figure 2 the variation of the asymmetry coefficient of the red line intensity on the solar equator of a time series which starts from the beginning of the data set and contains measurements collected with a time lag of 25 days is depicted. The positive values are almost two times larger than the negative ones, fact which supports an E-W asymmetry aspect.

In the figure 3 we present a summary of the above mentioned analysis for all the twenty five time series which start the first twenty five days of the period under consideration and contain measurements collected on the solar equator with a time lag of 25 days. Each point on this figure represents the average asymmetry coefficient of the corresponding time-series which has been marked on the horizontal axis by the initial rotation day. Numbers on the points of the figure refer to the number of measurements which contribute to the calculation of each point. Although the asymmetry coefficients have rather low values they are all positive. This fact supports the existence of an E-W asymmetry.

Figure 4 and 5 present an additional summary of our analysis for the data of both the green and red line, respectively. The horizontal axis of these figures represents the first 25 days of our data which are also the initial days of the time series we have considered.

From these two last figures, it is clear that in all the twenty five time series of the green line data and the additional twenty five of the red line data, $I_{\alpha}>I_{\omega}$ predominate systematically on the opposite case $I_{\alpha}<I_{\omega}$

In figure 4 where the green line data are represented, we almost find $I_{\alpha}>I_{\omega}$ Moreover, in figure 5 where the red line data are presented, we find $I_{\alpha}>I_{\omega}$ except in two cases where the opposite case occurs and 3-4 more cases where $I_{\alpha}\approx I_{\omega}$ It is possible that the limited sample of the red line data which is one third of that for the green line data introduces the above mentioned uncertainties.

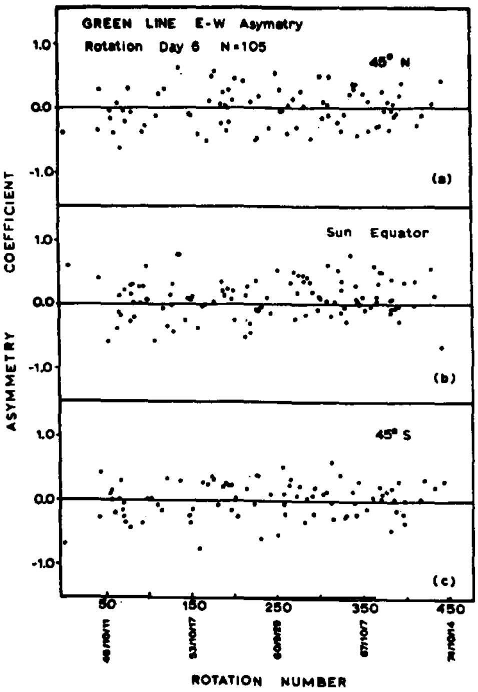

Figure 1: Variation of the asymmetry coefficient of the green line intensity at the solar equator (intermadiate panel) and at 45 deg. North and South heliolatitude (upper and low panel, respectively).

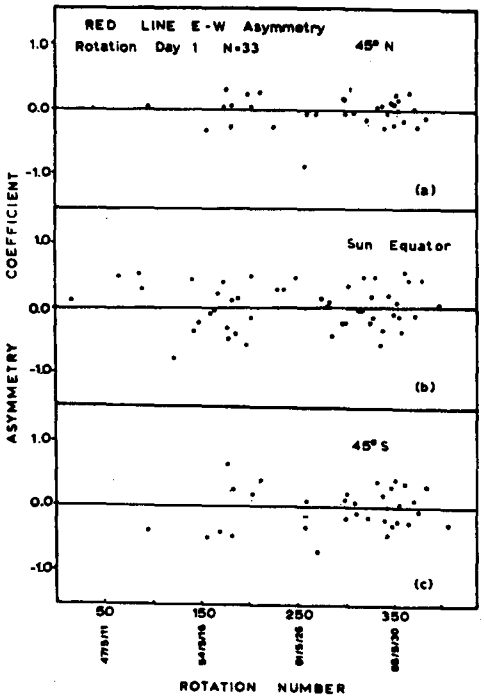

Figure 2: Variation of the asymmetry coefficient of the red line intensity at the solar equator.

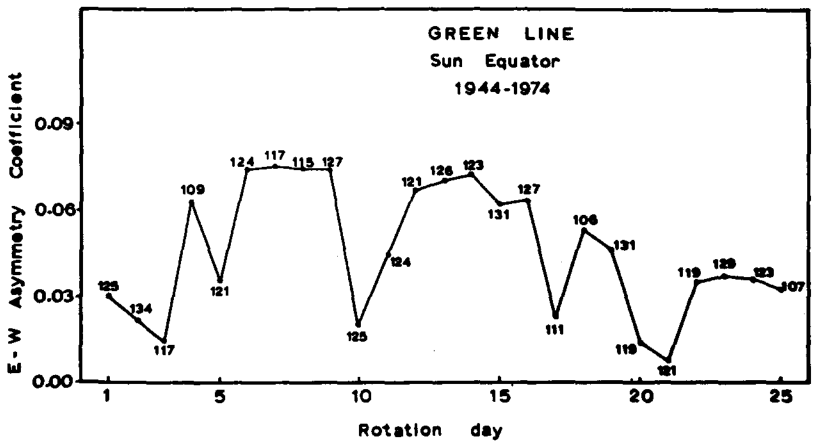

Figure 3: Variation of the mean asymmetry coefficient of the green line intensity of twenty five time series they start the first twenty-five days of our data period and contain measurements collected every 25 days. The number on each point refer to the number of values from which a certain mean asymmetry coefficient has been calculated.

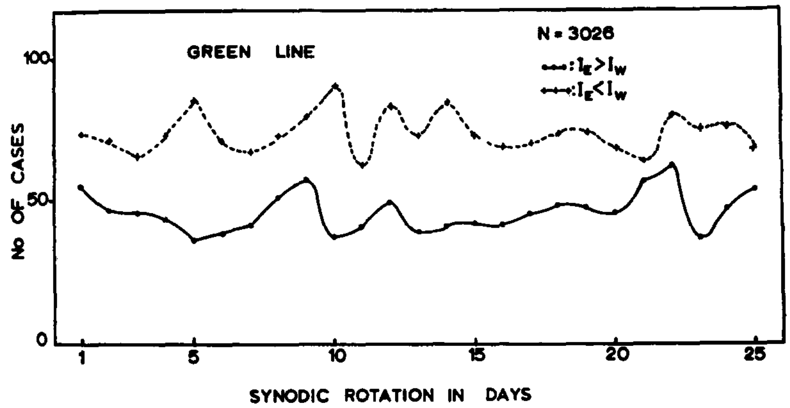

Figure 4: Number of cases where $I_E > I_W$ or $I_E < I_W$ in twenty-five time series which start the first twenty-five days of our data period and contain asymmetry coefficients which have been calculated every twenty-five days.

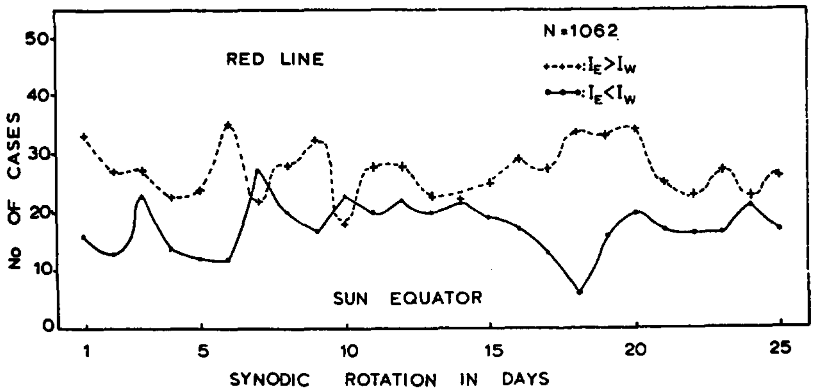

Figure 5: Figure similar to the figure 4 which refers to the red line intensities.

DISCUSSION

There are several temporal or observational reasons which could introduce the above mentioned E-W asymmetry in the green line intensity of the solar corona. Vibration of the solar disk due to seeing reasons behind the occultation disk of the coronagraph, collection of observations by different observers at different altitudes of the sun from the horizon in different positions of the sun on the ecliptic when the angle of the solar axis varies, are some of the reasons which could introduce such an asymmetry. However, the predominance of this effect on the green line in relation to the red one as well as a systematic seasonal variation which have been already detected in this asymmetry has almost convinced us that this E-W asymmetry is a real phenomenon. A detailed analysis of the Pic-du-Midi coronal data which will appear very soon will probably reveal the reason of the above reported effect.

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