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"EVIDENCE OF EAST-WEST ASYMMETRIES OF THE CORONAL GREEN AND RED LINE INTENSITIES ON THE SOLAR EQUATOR."

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A B S T R A C T

The analysis of daily measurements of the coronal green and red line intensities which have been collected by the Pic-du-Midi Observatory during the period 1944-1974 has revealed some very interesting features of these lines. The main point of this analysis is a strong evidence of East-West asymmetry of the green and red line intensity which has been determined all along the data record. In our effort to make this asymmetry certain, we have examined the ratio of the intensity measured on the East and the West solar limb as well as the E-W intensity differences very close to the solar equator where the rotation rate 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 that the above mentioned longitudinal asymmetry is a permanent phenomenon.

1.- INTRODUCTION

Highly ionized atoms of the solar corona, due to extremely high temperatures cause the green (F_eXIV $\lambda_{5303}A$) and the red (F_eX, $\lambda_{6374}A$) coronal emission lines. One of the most interesting features of these lines is some possible asymmetries which appear in their intensities. A North-South asymmetry of the green line intensity has been confirmed by many researchers. (Pathak, 1972; Rusin, 1980; Tritakis et al, 1988;) This asymmetry shows a negative correlation with the solar cycle activity in the sense that it is small in the maxima and high in the minima. In the opposite, some investigations for a possible E-W asymmetry of the green line intensity or other solar activity manifestations were not able to come to significant conclusions. There is only one case of a slight E-W asymmetry of the total spot areas which has been mentioned in the past. However, it has been explained as the result of a positive radial gradient of angular rotation of the Sun which caused the vertical axis of a sunspot to the titled westwards on the average by a half degree (Minneart, 1946;). The first report about an East-West asymmetry of the green line intensity, determined by the Pic-du-Midi data, has been anounced by Trellis in ashort communication in 1959. Few years ago, Tritakis et al (1988) examined the

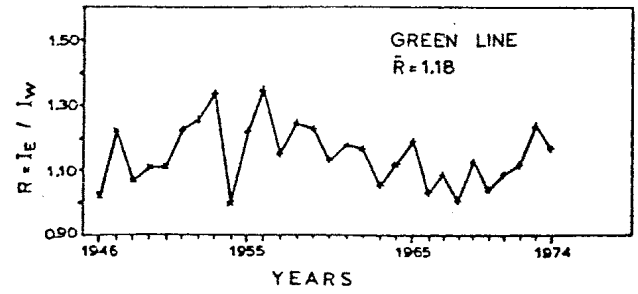
daily measurements of the green line intensity of the same Observatory for the period 1944-1974 and reported a significant E-W asymmetry all along the data record. In the present article we have tried to make this E-W asymmetry certain extending the work of Trellis for all the period 1944-1974 and examing the E-W intensity differences very close to the solar equator. In this way, data which almost correspond to the same points of the solar disk can confirm the above mentioned asymmetry. This research has been also extended to the study of possible E-W asymmetries in the red line intensities.

2.- DATA PROCESSING

In order to study the E-W asymmetry of the coronal green and red line intensities we have used daily measurements of these intensities taken from the Pic-du-Midi Observatory for the period 1944-1974. These measurements have been obtained by a classic Lyot-type coronagraph on heliocentric sectors every 5° around the solar limb in a distance from the Sun's edge which varies from 40" to 2". Hence our data have been obtained on 72 points around the solar limb starting from the North Pole (0 deg) and collecting measurements every 5° anticlock-wise. In a previous work, it was shown that these data were consistent to a homogeneous and free of trend time series (Tritakis et al., 1988). In this report we have used daily measurements of the green and red line intensities every twenty five days which correspond to the solar rotation days in the equator according to the expression $\Omega=14.28-0.4\ \sin^2\varphi$(deg/day) where Ω is the solar rotation frequency and φ is the solar latitude. Since we have studied data close to the solar equator (±5°), where the rotation rate is equal to 25.35 days on the average, we correct the starting time of the synodic rotation every 3-4 rotations by one day counterbalancing in this way a slippage by 0.35 day/rotation. Using this process, we succeed to compare data which almost correspond to the same points of the solar disk during succesive solar rotations from 1.1.1944 to 31.12.1974.

3.-LONGITUDINAL ASYMMETRIES IN THE GREEN AND THE RED LINE INTENSITIES

We have already remarked that the measurements of the 5303 Å line intensity in the corona obtained at Pic-du-Midi Observatory since 1947 showed a disymmetry between East and West limb of the Sun (Trellis, 1959; Tritakis et al, 1988). In order to define the reality of this disymmetry and to confirm the Trellis results we have taken for each day the average of the intensities for latitudes between -60° to 60° [30° < A_p < 150° for the East limb (i_e), 210° < A_p < 330° for the West limb (i_w)]. Then we computed the ratio, $R=I_E/I_W$ where I_E and I_W are averaged values of i_e and i_w for all the observations from 1944 to 1974. From this calculation, we take a mean value R=1.18 for the period 1944 to 1974. Computing the same ratio R for each year separately we observe that we have an extreme value for the year 1954 (Fig. 1). If we do not take into account this value we see that the ratio R becomes equal to 1.13 which confirms earlier calculations made by Trellis (1959) where this ratio had been estimated to 1.12. Since both of the above mentioned values of R are greater than one all along the data record it is reasonable to imply that a systematic disymmetry between the East and



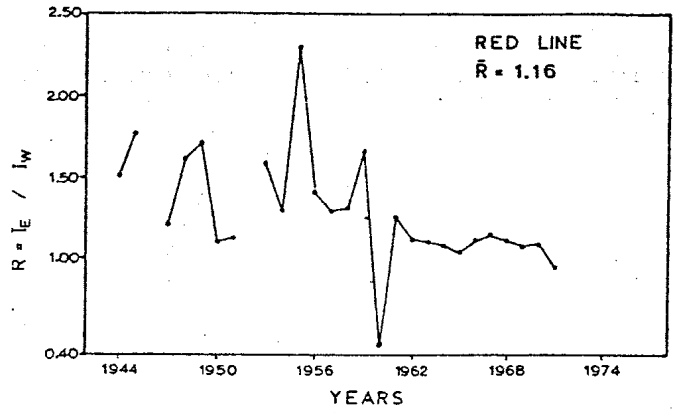


Fig. 1 and 2 Yearly values of the ratio $R=I_E/I_W$ for the green and red line intensity respectively.

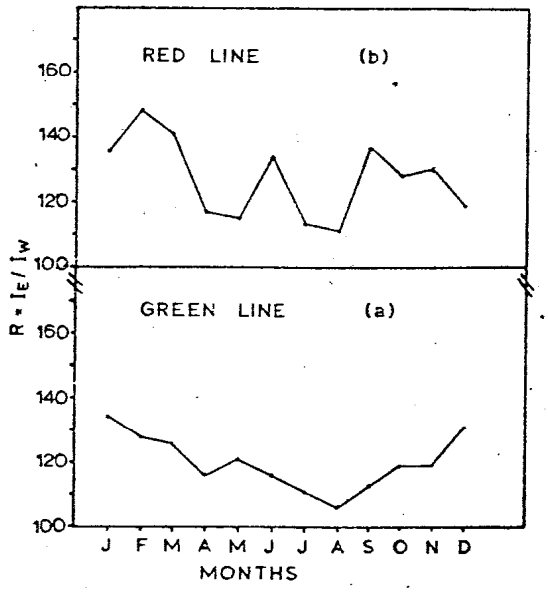


Fig. 3 Averaged annual varation of the ratio $R=I_E/I_W$.

West limb of the Sun is confirmed (Fig.1). The same work was done for the 6374 A line of $F_e(X)$ coronal ion The value of the ratio R for the period 1944-1974 was found R=1.26, thought Trellis (1959) for the same data of Pic-du-Midi Observatory for the time period 1944-1959 had found R=1.16 (Fig. 2). In the following, the study of the monthly averaged intensities I_E and I_W of the green and the red lines reveal another interesting effect. If we take into account values which have been averaged by three daily measurements of a certain month at least, we can calculate monthly values of the ratio R all along the time under consideration. In the Fig. 3 the seasonal variation of the quantity R for the green and the red line is depicted. There are two interesting things which could be denoted on this figure. The former is that the quantity R in both panels of the Fig. 3 is permanently greater than the unity which means that the average intensity of the East solar limb is greater than the one of the West. The latter is a modulation of the ratio I_E/I_W of one year period with an amplitude of $0.3X10^{-6}$ $R_\odot$. The maximum of this ratio for the green line (Fig. 3a) corresponds to January and the minimum in August, while for the red line (Fig. 3b) the maximum of this modulation appears in February and the minimum in August. It is very interesting that this result opposes to the relevant analysis of Trellis (1959) for the green line. Another way to represent the E-W asymmetry of the coronal radiation is to compute the East-West asymmetry coefficient of the green line intensity for each solar rotation day for the entire period 1944-1974, which is defined by the relation $A=I_E-I_W/I_E+I_W$ where I_E, I_W are values of the green and the red line intensity in the East and West limb of the Sun, respectively. The mean asymmetry coefficient of each rotation day for all the 25-day synodic rotations from 1944-1974 are presented in Fig. 4. From this Figure it is evident that there is a permanent but low E-W asymmetry coefficient of the green line intensity which implies that the east solar limb close to the equator is brighter from the west on the average. Another very interesting feature of the green line E-W asymmetry is obvious in Fig. 5. In this Figure monthly values of the green line intensity for the four quarters of the solar disk have been depicted. It is very clear that the NE solar quarter appears more active than the rest which might imply that E-W asymmetry of the coronal line intensities are caused by solar activity enhancements which prefer to establish in the NE solar quarter. However it is rather early to come to so daring conclusions.

4.-DISCUSSION AND CONCLUSIONS.

From the analysis which have been reported in the previous section of this article, it is implied that a permanent and significant E-W asymmetry of the coronal green and red line intensities which have been measured at the Pic-du-Midi Observatory, has been detected in the time period 1944-1974. A primary indication of this asymmetry has been detected by examining the Ratio $R=I_E/I_W$ on a yearly and monthly basis This Ratio is permanently greater than the unity, that is the intensity of the East solar limb is greater than the West. In addition, this Ratio represents an insisting oscillation on one year period the minimum of which occur in August and its maximum in the January-February period. Probably the contribution of the instrument to the formation of this disymmetry or observations which have been made in different height of the horizon as well as the method of

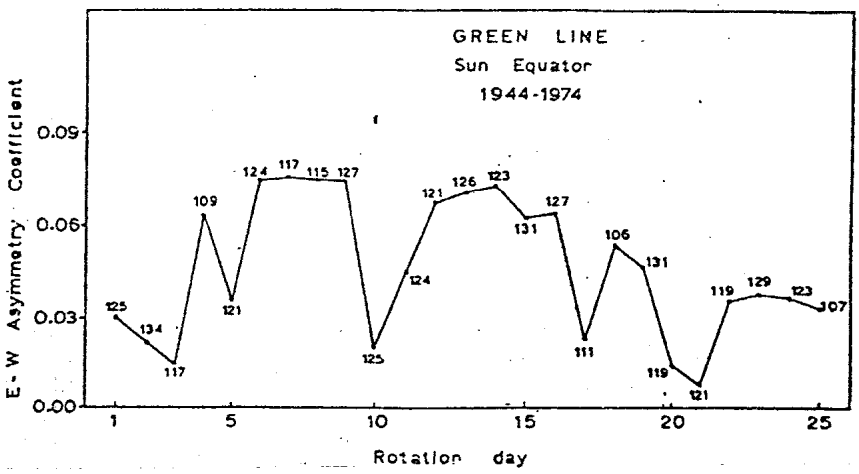


Fig. 4 Mean 25-day variation of the longitudinal asymmetry coefficient for all solar rotations. The numbers on the peaks are the number of the successive good rotations.

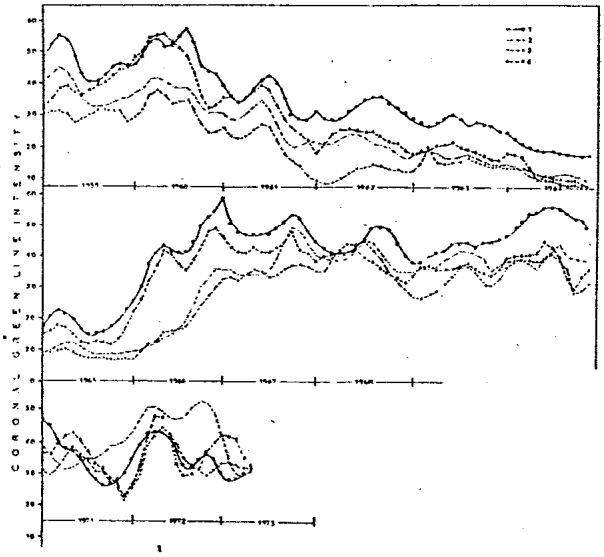


Fig. 5 Monthly values of the green line intensity for the span 1959-1973 for the four quarters of the solar corona. NE(1), SE(2), NW(3), SW(4).

taking the measurements would be affected this disymmetry.But the one year variation of this disymmetry allow us to relate it better with the position of the Earth on its orbit around the Sun. In the following, we have studied this disymmetry examining the E-W intensity differences very close to the solar equator where the rotation rate is equal to 25.35 days on the average. From this analysis we have conluded that an E-W asymmetry close to the solar equator is evident in both the green and the red line intensity. The physical mechanism of such asymmetry is not very clearly understood though both external and internal influences on the longitudinal distribution of the solar activity and related phenomena should contribute to the interpretation of this asymmetry. The motion of the Sun towards the Apex might apply an external influence on the longitudinal distribution of the solar activity while short-lived "active" solar longitudes which are formed by temporal clustering of solar active centers may probably manifest an important internal influence which lead to the formation of an E-W asymmetry (Trellis. 1967). Neverthless, the contribution of instrumental and observational reasons in the above mentioned asymmetries should be examined in a future work.

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