BEHAVIOR OF SOME FRAUNHOFER LINES AROUND MAXIMUM OF SOLAR ACTIVITY

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ABSTRACT: Equivalent widths of 18 Fraunhofer lines have been observed in integrated solar light from 1987 till 1992. Sixteen more dependable spectral lines out of 18 measured ones exhibit an extreme value (maximum or minimum) near the maximum of solar activity cycle.

1. INTRODUCTION

It is known that profiles of Fraunhofer spectral lines change with time (e.g. Babij 1976, Livingston and Holweger 1982, Babij 1991). There are indications that some of the line profile parameters (equivalent width, half- width (FWHM), line depth or line asymmetry) might change periodically–with the solar activity (e.g. Kharadze 1935, Derviz *et al.* 1961, Mitchell 1969, Stepanyan and Shcherbakova 1978, Livingston and Wallace 1987). This fact has to be confirmed and the mechanism of the changes identified.

Present paper deals with the sense and timings of the extreme values of equivalent widths of Fraunhofer lines near the maximum of solar activity.

2. OBSERVATIONS AND DISCUSSION

According to the concept given by Vince *et al.* (1988) a number of Fraunhofer lines have been observed at Belgrade Astronomical Observatory during the period 1987 – 1992. The instrument was described by Kubičela (1975) and Arsenijević *et al.* (1988), and the reduction procedure by Skuljan *et al.* (1992).

Equivalent widths of 18 Fraunhofer lines were observed in the light integated over the whole solar disk. As an example, results for four spectral lines are given in Fig. I, left side. The measured values are shown as dots and the fitted second degree polinomials as the solid lines. The evaluated moments of the extremes (maxima or minima) are shown as T.

All present results are given in Table 1 where wavelengths of the observed spectral lines are expressed in nanometers, the sense of the extremes of the polinomials is indicated by M for maxima and m for minima. T again presents the instants of the polinomial extremes. As it can be seen from the examples in Fig. 1, the noise of the measurements is not negligible. Standard deviations, S, of the scattered dots with respect to the fitted polinomials have been calculated. For the results having the overall absolute change of the polinomial smaller than the quantity $3Sn^{-2}$ (where $n = 25$ is number of observations of each line in six years) the extreme marks (M or m) in Table I have been put into brackets. The other ones we consider as statistcally more significant.

Table I *Measured Fraunhofer lines, sense (Ext.) and times (T) of the extreme values of the equivalent widths.*

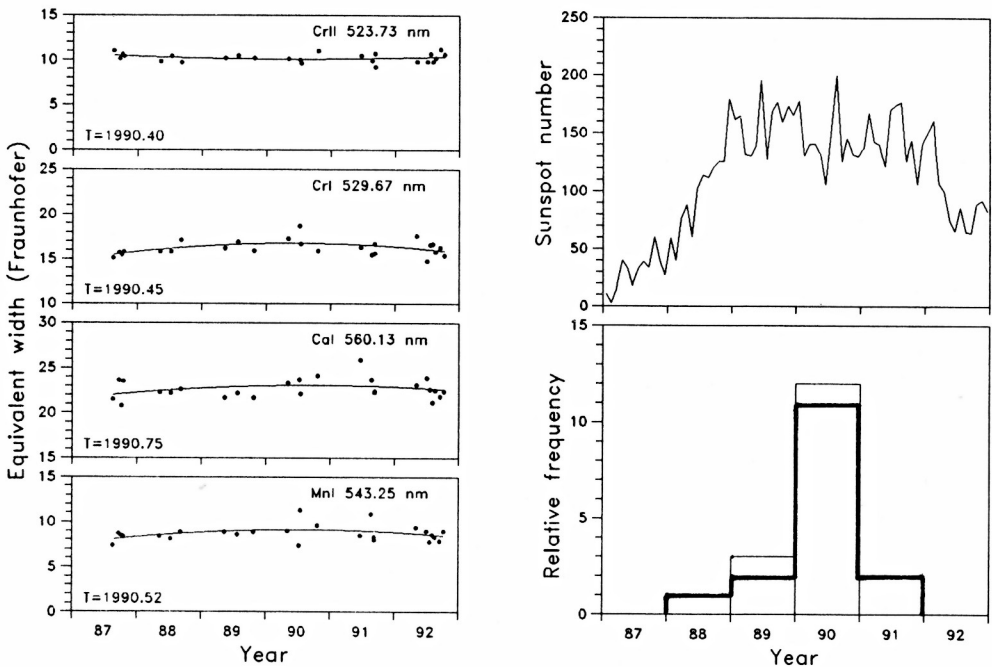| Line	Ext.	T	Line	Ext.	T	Line	Ext.	T
FeII 519.76	(M)	1989.27	TiII 533.68	M	1989.66	ScII 552.68	M	1990.53
CrII 523.73	m	1990.40	MnI 539.47	M	1989.57	FeI 557.61	(m)	1990.56
ScII 523.98	m	1990.73	FeI 539.83	M	1990.86	CaI 558.20	M	1991.43
CaI 526.17	M	1990.05	FeII 542.53	m	1988.76	CaI 560.13	M	1990.75
CrI 529.67	M	1990.45	MnI 543.25	M	1990.52	NaI 568.26	m	1990.45
FeI 530.74	M	1990.68	FeI 550.68	m	1990.44	NaI 568.82	M	1991.45

Fig. 1 *Left: equivalent widths (in fraunhofers) for some of the measured spectral lines (dots) and second degree polinomial fits (solid lines) during the years 1987 – 1992. The instants of the extreme values of the polinomials are given as T. Upper right: solar activity represented by relative sunspot number in the same interval. Lower right: distribution in time of the maxima and minima of the equivalent widths.*

The time–distribution of all measured equivalent width maxima and minima is shown in Fig. 1, lower right. Here the heavy line indicates the mentioned statistically more significant results. Comparing this distribution with variation of monthly mean

values of the sunspot number, upper right, one can imediately notice a definite time-coincidence of both maxima: of the sunspot number and of the equivalent width extremes distribution.

The median of the last distribution indicates the maximum at the year 1990.4. At the same time the mean T from Table I, taking into account only the more dependable cases, amounts to 1990.4. However, there are two maxima (or an extended one) in the sunspot data. It is well seen in Figure 1. According to the international sunspot data the maximum of the 22nd activity cycle happened at 1989.54 with smoothed sunspot number (SSN) amounting to 158 (Coffey 1993). During 1991, from January till August, there was a secondary maximum with the mean SSN=147. Taking the corresponding SSN values as weights, one can calculate the weighted mean instant of the "extended" sunspot maximum amounting to 1990.4.

One can not avoid conclusion that both phenomena, sunspots and the equivalent width extremes, define perhaps equally well the instant of the solar activity maximum. Indeed, the difference between the corresponding times is really very small. In this sense the variations of the solar global Fraunhofer line equivalent widths might be considered as an additional index of solar activity.

The question why some of the observed Fraunhofer line equivalent widths correlate and some of them anticorrelate with solar activity, for the time being, remains open.

REFERENCES

Arsenijević, J., Kubičela, A., Vince, I., and Jankov, S.: 1988, *Bull. Obs. Astron. Belgrade* **138**, 1.

Babij, B. T.: 1976, *Solnechnye Dann.* **4**, 80.

Babij, B. T.: 1991, *Kinematika i fizika nebesnyh tel* **7**, 16.

Coffey, . E.: 1993, *Solar–Geophysical Data* **584**, 31.

Dervize, T. E., Kuprevich, N. F., and Mitrofanova, L. A.: 1961, *Astron. Zhurnal* **38**, 448.

Kharadze, E. K.: 1935, *Zeitshr. Astrophys.* **10**, 339.

Kubičela, A.: 1975, *Publ. Astron. Obs. Belgrade* **20**, 47.

Livingston, W., and Holweger, H.: 1982, *Astrphys. J.* **252**, 375.

Livingston, W., and Wallace, L.: 1987, *Astrphys. J.* **314**, 808.

Mitchell, W. E.: 1969, *Astrophys. J.* **155**, 709.

Skuljan, J., Erkapić, S., Vince, I., and Kubičela, A.: 1992, *Bull. Astron. Belgrade* **145**, 157.

Stepanyan, N. N., and Shcherbakova, Z. A.: 1978, *Izv. Krym. Astrophys. Obs.* **58**, 3.

Vince, I., Kubičela, A., and Arsenijević, J.: 1988, *Bull. Astron. Belgrade* **139**, 25.