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INFLUENCE OF TEMPERATURE GRADIENT CHANGES ON SOLAR SPECTRAL LINE PROFILE PARAMETERS

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SUMMARY: In this paper we examine, theoretically, the influence of temperature gradient changes on 27 spectral line profiles.

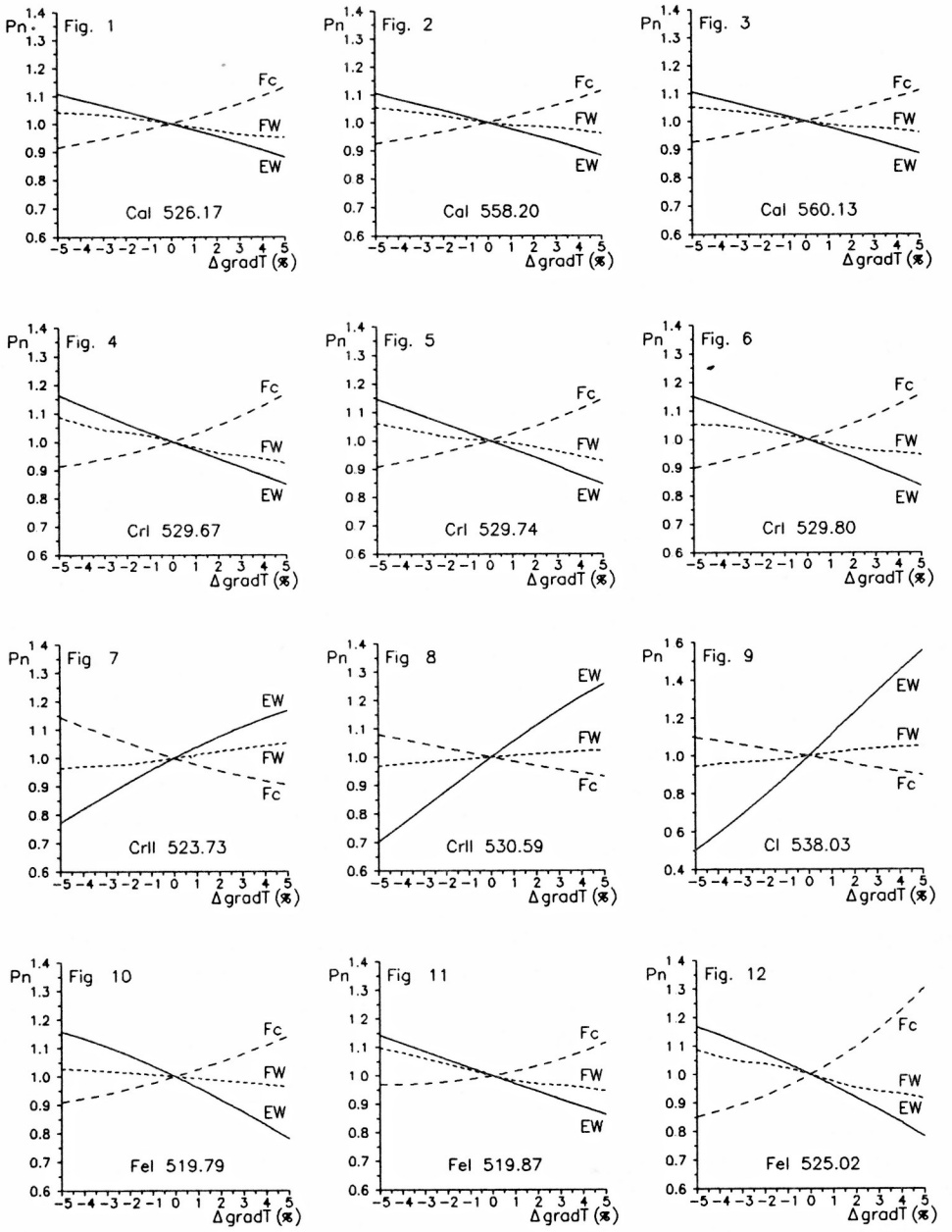
A long-term observational program of 31 selected solar spectral line profiles has been carried out at Astronomical Observatory in Belgrade since 1987 (Vince et al. 1988). It has been shown that long-term changes of spectral lines are present and related probably to the solar activity (Skuljan et al. 1992). In present paper we examine, theoretically, the influence of temperature gradient changes on those 31 spectral line profiles from our observation program.

Under the assumption that for those spectral lines the LTE is valid, we calculated the synthetic spectral line profiles using the model of solar atmosphere given by Maltby et al. (1986). The line profile calculations refer to integrated solar flux radiation. Four spectral lines were excluded from further analysis because the non-LTE effects influence them prominently.

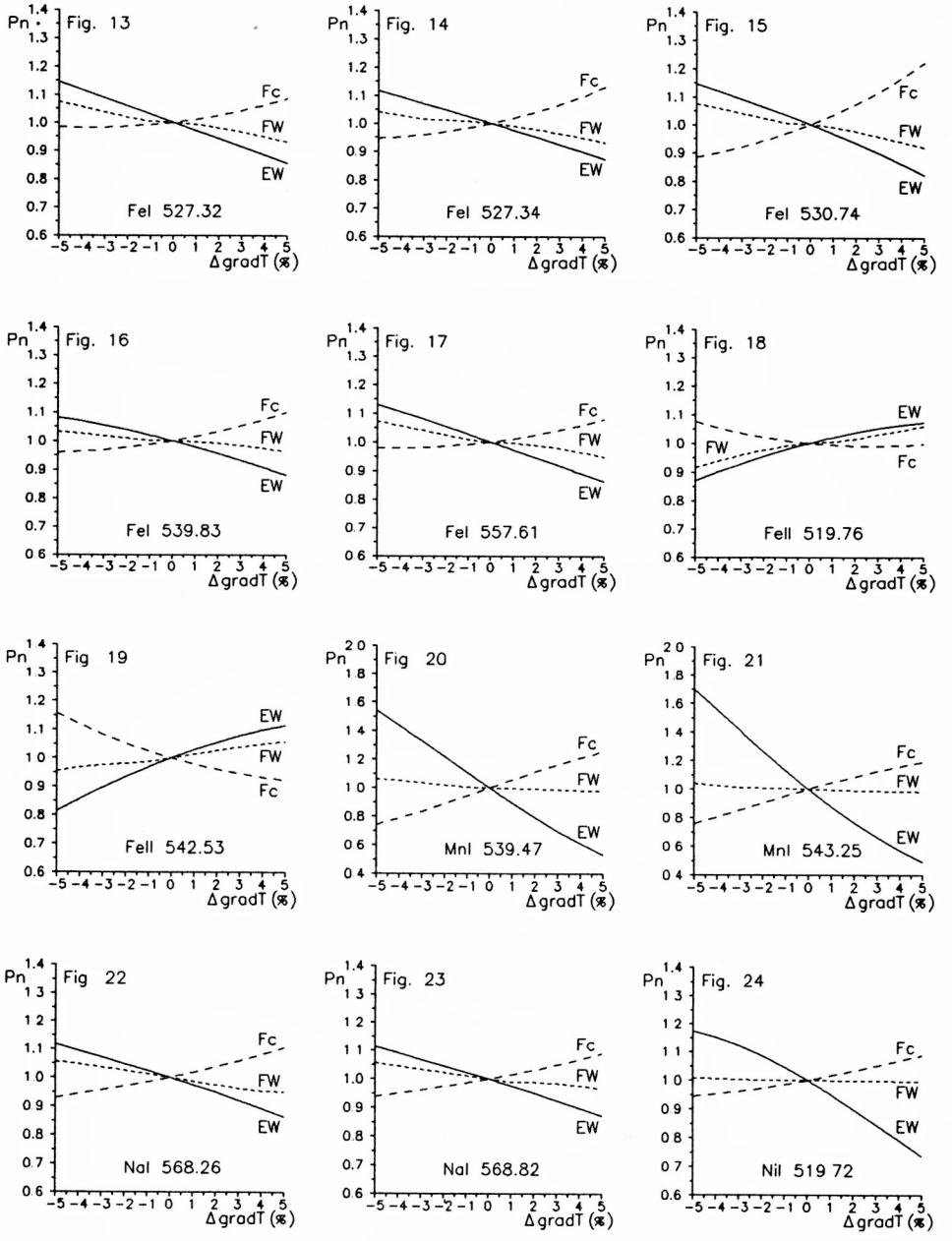
By variation of temperature gradient in the model up to $\pm 5\%$ we calculated the relative changes of equivalenth width (EW), full half-width (FW) and relative central flux (F_c) for 27 spectral lines. The calculation results are given in Figures 1-27., where relative variations of these parameters normalized to their unchanged model values are ploted against temperature gradient changes.

According to the general behaviour of the line parameter changes, we can devide the spectral lines into two groups. The spectral lines of the first group show increase of EW and FW, and decrease of F_c with positive changes of temperature gradient. All single-ionized atom lines and the CI 538.03 neutral atom line belong to this group. This behaviour of equivalent width variation, for instance, we can explain on the basis of simplified line formation theory (Gray, 1976), according to which the steepness of temperature gradient influence on EW-changes depends on ionization energy. The ionization energy is always positive, consequently the EW-change is positive too. The spectral lines of the second group show line parameters variations opposite of the first group. To this group belong all spectral lines of neutral atoms except CI 538.03 line. For these lines the steepness depends on the difference of excitation and ionization energy (E_{ex}-E_i), which is always negative ($E_{ex} < E_i$), consequently the EW-change is negative too.

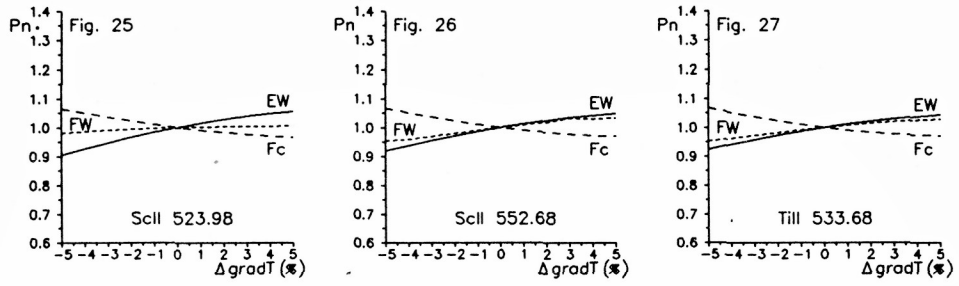
Detailed examination of graphs in Figures 1-27. shows that certain lines are very sensitive to the temperature change. Especially significant are the changes of equivalent widths of CI 538.03, MnI 543.25 and MnI 539.47. The temperature sensitiveness of CI 538.03 line is due to the fact that this line is formed very deep in solar photosphere (almost coincident with the continuum) where temeperature gradient is relatively high. Among all lines the MnI 539.47 line shows the greatest change in equivalent width. This great gradient is due to the large difference of the excitation



Figs. 1-12. Relative changes of normalized parameters (P_n: EW – equivalent width, FW – full half-width, F_c – central flux) with temperature gradient in percents



Figs. 13-24. Same as in Figures 1-12.



Figs. 25-27. Same as in Figures 1-12.

(E_{ex}=0 eV) and ionization energy (E_i=7.437 eV) of this ground-state line. The same explanation is valid for MnI 543.25 line. The profiles of a vast majority of lines are not so sensitive to the temperature changes.

On the basis of our analysis we can also say that it could not exist neither functional nor correlational connection between the changes of solar spectral line profile parameters and excitation energy of the lower energy level, because these parameters are not only sensitive to the excitation energy, but also to the temperature, to the ionization potential and, in some cases, to the electron pressure, too. Consenquently, some investigators' attempts (e.g. Babij, 1991) to find such correlations were unsuccessful.

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