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C. Marmolino, G. Roberti*, G. Severino*

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G. Roberti

Dipartimento di Fisica N.S.M.F.A., Universita de Napoli, Mostra d'Oltremare, Pad. 20
80125 Napoli, Italia

G. Severino

Osservatorio Astronomico di Capodimonte, Via Moiariello, 16, 80131, Napoli, Italia

PHYSICS OF FORMATION OF FeII LINES OUTSIDE LTE

PROCEEDINGS OF THE 94TH COLLOQUIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN ANACAPRI, CAPRI ISLAND, ITALY, 4–8 JULY 1986

Edited by

ROBERTO VIOTTI
Istituto di Astrofisica Spaziale (CNR), Frascati, Italy

ALBERTO VITTONE
Osservatorio Astronomico di Capodimonte, Napoli, Italy

and

MICHAEL FRIEDJUNG
Institut d'Astrophysique (CNRS), Paris, France

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FE II LINES IN THE PRESENCE OF PHOTOSPHERIC OSCILLATIONS

C. Marmolino
Air Force Geophysics Laboratory
National Solar Observatory/Sacramento Peak
Sunspot, N.M. 88349 U.S.A.,
on leave from the Università di Napoli

G. Roberti
Dipartimento di Fisica N.S.M.F.A.,
Università di Napoli .
Mostra d'Oltremare, Pad.20
80125 Napoli, Italia

G. Severino
Osservatorio Astronomico di
Capodimonte,
Via Moiariello, 16
80131 Napoli, Italia

1. INTRODUCTION

Line asymmetries and wavelength shifts can be produced by dynamical processes at work in the solar photosphere. Dravins, Nordlund and coworkers (ref.1,2,3) discussed the importance of the granulation in determining the C-shape of solar lines of FeI and FeII ions. Iron is a suitable atomic species to diagnose photospheric motions, since it has negligible asymmetries due to isotope composition and to pressure shifts and no hyperfine structure splitting. Marmolino, Roberti, Severino and coworkers studied the effects produced by photospheric oscillations (5 - min and short period acoustic waves) on the resonance line of KI at 7699 A (ref. 4,5,6). To extend this study to iron lines, in this paper we show the synthesis of the FeII 6516 line in the presence of granulation and 5 - min oscillation.

The granulation model is that by Nelson (ref.7) with the velocity amplitude increased by a factor 1.5, as in ref.6. The wave model is a monochromatic evanescent wave having a period of 300s and a velocity amplitude of 350 m/s at z=0, sligthly increasing with height. The line synthesis code allows for the use of non-LTE atomic level populations computed in the unperturbed model. However for the Fe II 6516 our LTE calculations with the VAL C atmosphere (without microturbulence), an Fe abundance of 2.51×10^7 and the atomic data taken from ref.8, give a satisfactory comparison with the observed line profile from the Jungfrau Atlas (ref.9)

R. Viotti et al. (eds.), Physics of Formation of FeII Lines Outside LTE, 217–221.

(Fig.1).

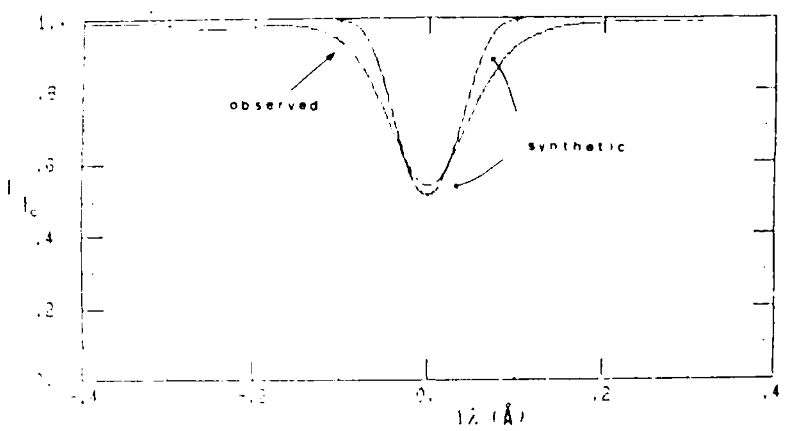

Figure 1. Synthetic vs.observed profile of the FeII 6516.081 line at disk center.

2. RESULTS

The asymmetry of the spatially resolved profiles in the presence of granulation is much stronger than that of the mean, unresolved profile (Fig.2). The bisector of the resolved profiles measures the vertical velocity gradients within the granulation, while the asymmetry of the mean profile is a combined effect of the different line shifts, different line strengths and different continuum intensities between the granular and intergranular components. This effect leads to a blueshift of the spatially averaged line profile corresponding to a velocity of 360 m/s in the center of gravity.

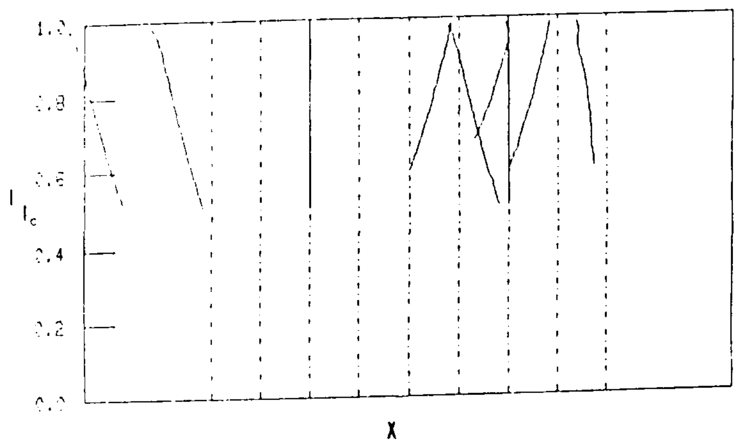

Figure 2. Bisector vs. horizontal coordinate in the presence of granulation. The last bisector refers to the spatially averaged profile. Note that the vertical dotted-dashed lines mark the positions of the unperturbed bisectors and the separation of two successive lines is of 584 m/s in velocity scale.

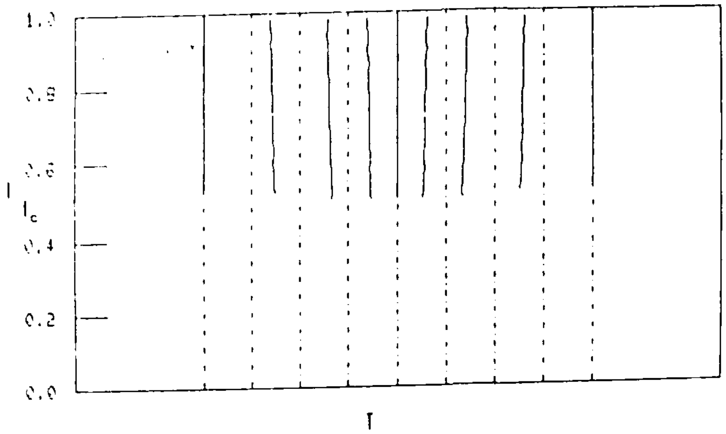

Figure 3. Bisector vs. time in the presence of 5-min oscillation. The last bisector refers to the temporally averaged profile.

The line bisector produced by the 5-min oscillation are plotted in Fig.3 as a function of the time. At each time the line bisector is roughly proportional to the vertical velocity vs. depth. The phase relations among the perturbations in the evanescent wave (dT and dP are 90 degree out of phase respect to v) ensure that when the velocity takes opposite values the thermodynamic structure is unchanged and the resulting profiles are mirror symmetric. Then the temporally averaged profiles has neither asymmetry nor shift.

When both granulation and 5-min oscillation are present, the general behaviour of the spatially averaged line bisector vs. time is just the temporal fluctuation of the spatially mean C-shape due to the granulation (Fig.4). This agrees with the finding of Roca-Cortes et al. (ref. 10) for the KI 7699 line that the asymmetry is anticorrelated with the core shifts due to the 5-min oscillation.

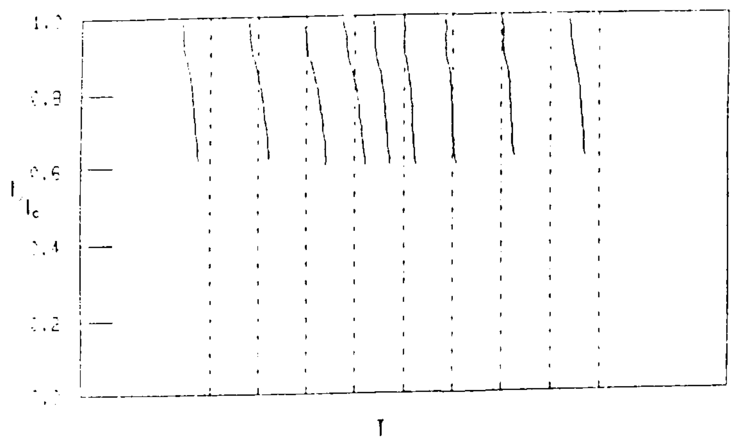

Figure 4. Bisector vs. time in the presence of the both granulation and 5-min oscillation. All bisectors are spatially averaged. The last bisector refers to the spatially and temporally averaged profile.

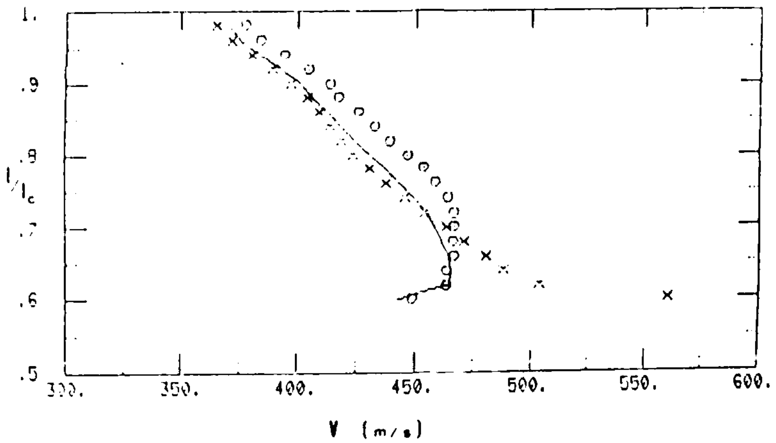

Figure 5. Residual intensity vs. amplitude of the velocity of fluctuations in presence of both granulation and 5-min oscillation. Crosses: blue line flank; solid line: line bisector; circles: red line flank.

Examining the line profiles, we have found that, when the granulation is present, the oscillations do not equally affect the two line flanks, as shown in Fig.5. The blue flank oscillates with a velocity amplitude lower than the red flank does, down to I/Ic ~ 0.65. At I/Ic < 0.65 this situation reverses. The velocity amplitude of the bisector points are approximatively the average of those of the flanks. These results seem to confirm the findings by Cavallini et al. (ref.11) for three FeI lines. However there are two main differences between their observations and our line synthesis:

i) Cavallini et al. measured oscillations down to I/Ic = 0.4, while our FeII 6516 line has a central depth of only I/Ic ~ 0.55;

ii) the velocity amplitude of the line bisector observed by Cavallini et al. is of the order of 40 m/s, i.e. a factor 10 smaller than our calculations and also than the values commonly accepted for the velocity amplitude of the 5-min oscillation.

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