Rev. Mexicana Astron. Astrof., **21**, 409-412 (1990)

SYNTHETIC CAII TRIPLET LINES

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RESUMEN. Se hicieron cálculos de síntesis del espectro en el intervalo de longitud de onda λλ8300 - 8700 A, para poder verificar el comportamiento de diferentes líneas moleculares y atómicas como función de los parámetros estelares de temperatura, gravedad y metalicidad. El espectro sintético ha sido generado para: (a) todas las líneas, (b) solamente líneas de CN, (c) solamente líneas de TiO, y (d) solamente líneas atómicas.

Abstract. Spectrum synthesis calculations are carried out in the wavelength interval λλ 8300 - 8700 A, in order to verify the behaviour of different molecular and atomic lines as a function of the stellar parameters temperature, gravity and metallicity. Synthetic spectra were generated for: (a) all lines, (b) only CN lines, (c) only TiO lines, and (d) only atomic lines

Key words: LINE-PROFILE — STARS-ATMOSPHERES

I. Introduction

The infrared CaII triplet is the strongest set of metallic lines in the near infrared (λ8498, λ8542, λ8662 A), being easily observable in the spectra of galaxies and globular clusters.

Traditionally the infrared CaII triplet has been considered as a good luminosity indicator since the work by Merrill (1934). Recent studies by Jones et al. (1984) show that the equivalent width of the feature presents a strong one-valued correlation with the surface gravity, being therefore specially useful as a dwarf:giant discriminator, while only a weak correlation with the metallicity was found. More recently, however, a study by Bica and Alloin (1987) of a sample of globular clusters of several ages and metallicities shows that the metallicity is the most important parameter dominating the strength of the CaII λ8542 A line. Diaz et al. (1989) also analyzed the behaviour of the CaII infrared lines for a sample of 106 late type stars of different effective temperatures, surface gravities and metallicities, and find a biparametrical behaviour with surface gravity and metal abundance in the sense that the strength of the feature increases with increasing abundances and with decreasing gravities.

In the present work, a detailed study of the spectral region λλ 8300 - 8700 A, comprehending the CaII triplet lines, is done, in view of establishing evidences for its behaviour as a function of stellar parameters.

Our procedure based on the construction of a grid of synthetic spectra, differently from the one used by Diaz et al. (1989) based on observed stellar spectra, makes it easier to disentangle the behaviour of the different components constituting the feature. Furthermore, it allows the inclusion of spectra of super metal rich stars, such stars being observable only at faint magnitudes.

II. Calculations

The calculations were carried out for stars of different spectral types in the interval λλ 8300 - 8700 A and we show the contribution of the atomic and molecular lines present in this region as a function of stellar temperatures, gravities and metallicities.

The molecular lines considered are the bands of the CN red system ($A^2\Pi$ - $X^2\Sigma$) and TiO γ-system ($A^3\Phi$ - $X^3\Delta$). More than 700 rotational lines of the CN red system belonging to the vibrational transitions (2,0), (3,1), (4,2) and (5,3) were included, where the wavelengths are taken from Davis and Phillips (1963). For the TiO γ system, about 3000 rotational lines are present, belonging to the vibrational transitions (0,2), (1,3) (2,4) and (3,5). The list of lines are from Phillips (private communication). The atomic lines are those included in the list of Swensson et al. (1974), and the oscillator strengths were fitted one by one to the solar spectrum (Delbouille et al., 1973). For more details see Erdelyi-Mendes and Barbuy (1989).

The fluxes were computed using the code of spectrum synthesis as described in Barbuy (1981, 1989) and Barbuy et al. (1989), which is an extension of the code for atomic lines by Spite (1967). The wavelength step of the flux calculations was 0.02 A. The model atmosphere employed were obtained by interpolation in the grids by Gustafsson et al. (1975) for giants, and subsequent unpublished grids by these authors, for dwarf and metal-rich stars. The microturbulence velocity adopted for dwarfs was 1 km s^{-1} and for giants the value 1.8 km s^{-1} was considered.

III. Results

In table I is given the grid of stellar model parameters considered. The synthetic fluxes were computed considering: (i) all lines, (ii) only CN lines, (iii) only TiO lines and (iv) only atomic lines, in order to analyze the contribution of different components to the total flux.

Figure 1, 2, 3 show the behaviour of the CN, TiO, atomic lines, and all lines in stars of different stellar parameters, where a convolution step of 1.5 A was employed. The main conclusions are as follows: (a) The CN lines are stronger in giants than in dwarfs (figure 1); (b) TiO lines are relatively insensitive to gravity, being practically as strong for a dwarf as for a giant star of similar temperatures and gravities; (c) The intensity of the CN

Table I - List of stellar parameters temperature, gravity, metallicity and microturbulence velocity considered

T_{eff}	log g	|M/H|	v_t
0.86	4.44	0.0	1.0
0.86	4.44	-1.0	1.0
0.86	4.44	+0.6	1.0
0.86	3.25	0.0	1.0
0.86	3.25	-1.0	1.0
0.86	3.25	+0.6	1.0
1.07	4.50	0.0	1.0
1.07	4.50	-1.0	1.0
1.07	4.50	+0.6	1.0
1.07	1.50	0.0	1.8
1.07	1.50	-1.0	1.8
1.07	1.50	+0.6	1.8
1.23	4.50	0.0	1.0
1.23	4.50	-1.0	1.0
1.23	4.50	+0.6	1.0
1.23	0.50	0.0	1.8
1.23	0.50	-1.0	1.8
1.23	0.50	+0.6	1.8
1.36	-0.20	0.0	1.8
1.36	-0.20	-1.0	1.8
1.36	-0.20	+0.6	1.8

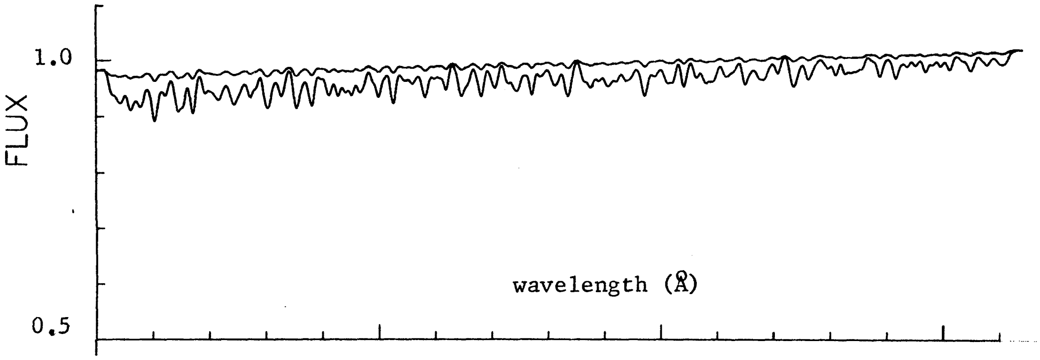

Figure 1 - CN lines for the stellar parameters Θ_{eff} = 1.07, |M/H| = 0.0 and log g = 1.50 and 4.50, showing the effect of gravity on the strength of the CN lines

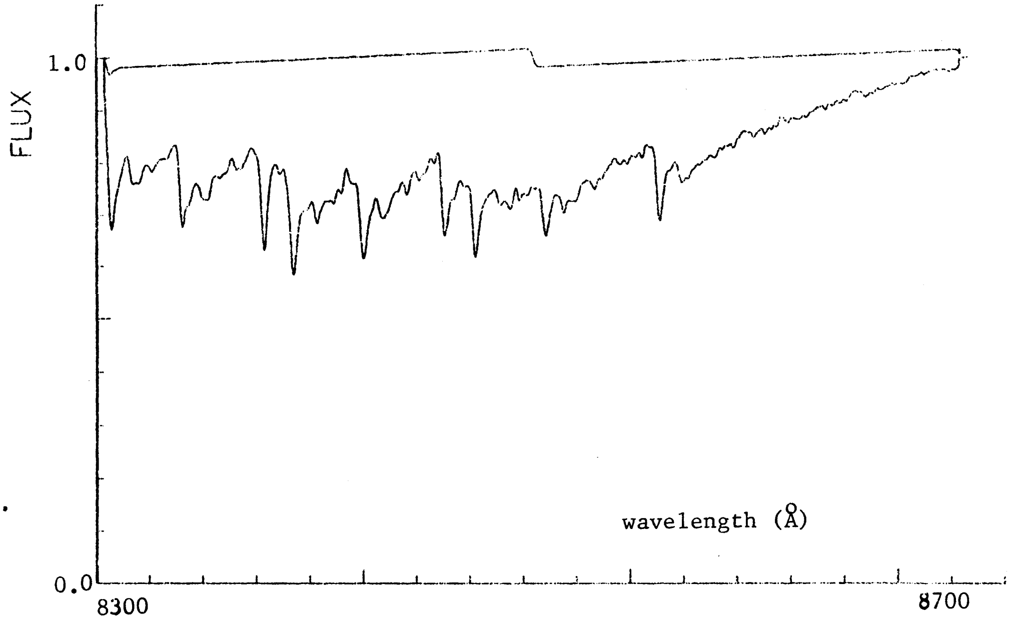

Figure 2 - TiO lines for the stellar parameters Θ_{eff} = 1.36, log g = -0.20 and |M/H| = -1.0 and +0.6, showing the effect of a change in metallicity

lines are slightly stronger for temperatures aroung T_{eff} = 4000 K (corresponding to a spectral type K0) and decrease for temperatures below this. This can be due to the molecular association of CO, which becomes dominant, reducing the number of free C atoms; (d) The TiO bands become sensitively stronger with decreasing temperatures, being almost absent for $T_{eff} > 4500$ K (corresponding to types earlier than G5); (e) The intensity of the CN and TiO lines increases with the square of the metallicity, given that these are diatomic molecules. This is illustrated in figure 2; (f) The effect of considering molecular lines in the calculations is shown in figure 3, where calculations for TiO lines and for all lines, for a same model atmosphere, are done. It can be seen that the inclusion of the TiO lines lowers considerably the apparent continuum for spectral types later than K0, being negligible for earlier types.

IV. Conclusions

The construction of a grid of synthetic spectra for stars of different stellar parameters allows the inspection of the behaviour of the atomic and molecular lines present in the wavelength region λλ 8300 - 8700 A, as a function of these parameters. This method is powerful since it permits the separation of the spectrum in its constituents.

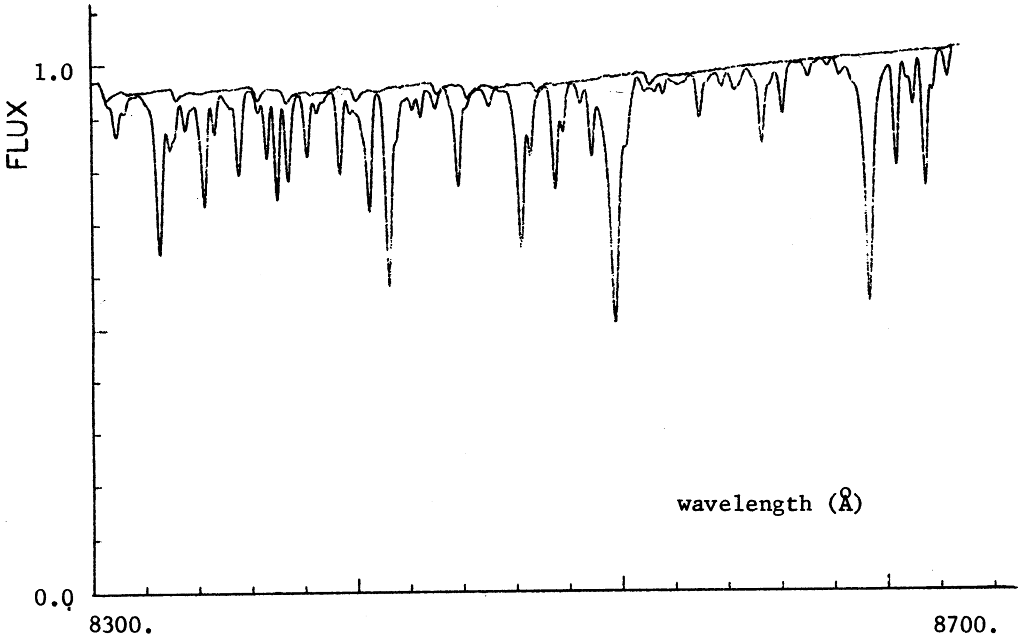

Figure 3 - Spectra computed with all lines and only TiO lines, for stellar parameters Θ_{eff} = 1.23, log g = 4.50, |M/H| = +0.6.

The possibility of inclusion of super metal rich stars makes this procedure very useful for the build up of a stellar population synthesis data base. According to O'Connell (1986), one of the major limitations for the population synthesis technique is the incompleteness of the spectral libraries used.

Acknowledgements: The calculations were carried out at the Burroughs 6900 of the University of São Paulo and at the VAX 8530 of the Astronomy Department of the University of São Paulo. This work was partially supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp) and the Conselho Nacional de Pesquisas (CNPq). M.E.M. acknowledges fellowship no. 85/3644-4.

References

Barbuy, B.: 1981, Astron. Astrophys. 101, 365
Barbuy, B.: 1989, Astrophys. Spa. Sci. 157, 111
Barbuy, B., Perrin, M.-N., Cayrel, R.: 1989, Astron. Astrophys., submitted
Bica, E., Alloin, D.: 1987, Astron. Astrophys. 186, 49
Davis, S.P., Phillips, J.G.: 1963, "The Red system ($A^2\Pi - X^2\Sigma$) of the CN molecule", University of California Press
Delbouille, L., Roland, G., Neven, L.: 1973, "Photometric Atlas of the Solar Spectrum from 3000 to 10000 A", Institut d'Astrophysique de Liège, Belgium
Diaz, A.J., Terlevich, E., Terlevich, R.: 1989, Mon. Not. Roy. Astron. Soc., in press
Erdelyi-Mendes, M., Barbuy, B.: 1989, Astron. Astrophys. Suppl. 80, 101
Jones, J., Alloin, D., Jones, B.J.T.: 1984, Astrophys. J. 283, 457
Merrill, P.: 1934, Astrophys. J. 79, 183
O'Connell, R.W.: 1986, in "Stellar Populations", STScI Conference, Eds. C.A. Norman, A. Renzini, M. Tosi, p. 167
Spite, M.: 1967, Ann. Astrophys. 30, 211
Swensson, J.W., Benedict, W.S., Delbouille, L., Roland, G.: 1974, "The Solar Spectrum from 7498 to 12016 A", Institut d'Astrophysique de Liège, Belgium

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