Star Formation Processes and Chemical Evolution:

More Poster Papers

https://doi.org/10.1017/S0074180900204361 Published online by Cambridge University Press

The Stellar Content of Local Group Galaxies
IAU Symposium, Vol. 192, 1999
Patricia Whitelock and Russell Cannon, eds.

New Grids of Synthetic Spectra for Abundance Derivation and Population Synthesis

B. Barbuy

Universidade de São Paulo, C.P.3386, São Paulo 01060-970, Brazil

M.-N. Perrin, R. Cayrel, D. Katz, C. van't Veer

Observatoire de Paris, 61, av. de l'Observatoire, 75014 Paris, France

R.P. Schiavon

Observatório Nacional, R. Gen. José Cristino 77, 20921-400 Rio de Janeiro, Brazil

Abstract. We have built a new grid of synthetic spectra in the wavelength range $\lambda\lambda$ 4600-5600 Å for [α-elements/Fe] = 0.0, +0.2, +0.4 and +0.6. The Lick indices Mg_2, Mgb, Fe5270 and Fe5335 are measured in all grid spectra, and their behaviour with stellar parameters is studied.

For the calculation of this new grid, the set of atomic and molecular constants was revised and model atmospheres with overshooting and mixing length parameters appropriate to reproduce the wings of the Hβ line (suitable to indicate temperatures) were computed. We also present a grid in the wavelength range $\lambda\lambda$ 6000 - 10200 Å. A computation of a high-resolution grid of spectra in the range $\lambda\lambda$ 3800-7000 Å, as well as a full grid in the range $\lambda\lambda$ 3000-10200 Å, to be further used in conjunction with evolutionary population synthesis models, are also underway.

1. Introduction

The indices Mg_2, Mgb, Fe5270 and Fe5335 defined by the Lick group (Burstein et al. 1984; Faber et al. 1985) and redefined in Worthey et al. (1994) are of widespread use for measuring the metallicity of globular clusters and normal galaxies (see Trager et al. and references therein).

Calibrations of these indices as a function of stellar parameters, using measurements for individual observed stars have been carried out by several authors such as Buzzoni et al. (1992), Gorgas et al. (1993), Worthey et al. (1994), Idiart & Freitas Pacheco (1995). Values derived from the computation of synthetic spectra were presented by Gulati et al. (1993), where the ATLAS code, and line lists and model atmospheres by Kurucz (1992) were employed; Barbuy (1994) computed Mg_2 for representative stellar evolutionary stages of globular clusters, for metallicities in the range $-2.0 <$ [Fe/H] $< +0.5$, and composite spectra for single-aged populations, deriving a calibration of Mg_2 vs. [Fe/H] and [Mg/Fe].

Such calibrations are fundamental for the understanding of the behaviour of these indices in composite systems.

In the present work we compute synthetic spectra, using revised lists of atomic and molecular data, revised model atmospheres, and extended in wavelength and temperatures relative to Cayrel et al. (1991). The Mg_2, Mgb, Fe5270, Fe5335 indices are measured on all the grid spectra.

2. Calculations

The code for spectrum synthesis is an improved version (Barbuy et al. 1998), relative to previous versions, where the main improvements are the inclusion of hydrogen lines and calculations are made far faster by computing in steps of 100 Å. LTE is assumed for the synthesis.

Abundances are adopted from Grevesse et al. (1996). Oscillator strengths for atomic lines are adopted from Fuhr et al. (1988), Martin et al. (1988) and Wiese et al. (1969) whenever available, otherwise they were obtained by fitting the solar spectrum.

The molecular lines of the following molecules were taken into account in the calculations: MgH ($A^2\Pi$-$X^2\Sigma$), C_2 ($A^3\Pi$-$X^3\Pi$), CN blue ($B^2\Sigma$-$X^2\Sigma$), CH ($A^2\Delta$-$X^2\Pi$), CH ($B^2\Delta$-$X^2\Pi$), CN red ($A^2\Pi$-$X^2\Sigma$), TiO α ($C^3\Delta$-$X^3\Delta$) and TiO γ ($A^3\Phi$-$X^3\Delta$). For the red, TiO γ' ($B^3\Pi$-$X^3\Delta$), δ ($b^1\Pi$-$a^2\Delta$), ϵ ($E^3\Pi$-$X^3\Delta$), ϕ ($b^1\Pi$-$d^1\Sigma$), and FeH ($A^4\Delta$-$X^4\Delta$) are also included.

Atmospheric models for the hotter temperatures ($4750 \leq T_{\rm eff} \leq 7000$) were computed using the ATLAS code by R. Kurucz. For $3500 \leq T_{\rm eff} \leq 4500$ the model atmosphere grid by Kurucz (1992) was used. For stars cooler than 3500 K models by Plez et al. (1992), Plez (1997, unpublished) and Allard & Hauschildt (1995) were employed.

3. Grids of Synthetic Spectra

Grid 1 (Barbuy et al. 1998): The grid comprises 7040 synthetic spectra in the wavelength range $\lambda\lambda$ 4600-5600 Å, effective temperatures $3500 \leq T_{\rm eff} \leq 7000$ K, gravities $0.0 \leq \log g \leq 5.0$, metallicities $-3.0 \leq$ [Fe/H] $\leq +0.3$ and [α-elements/Fe] = 0.0, +0.2, +0.4 and +0.6

Using Grid 1, we measured the old (Burstein et al. 1984; Faber et al. 1985) and new (Worthey et al. 1994) Lick indices Mg_2, Mgb, Fe5270 and Fe5335 over the whole grid of synthetic spectra.

In Fig. 1 is shown Mg_2 vs. [α/Fe] for ($T_{\rm eff}$, $\log g$) = (4000, 2.0). Note that the relation is essentially linear, where $Mg_2 \propto 0.4$ [α/Fe].

Grid 2 (Schiavon & Barbuy 1998): The grid comprises 906 synthetic spectra in the wavelength range: $\lambda\lambda$ 6000-10200 Å with effective temperatures $2700 \leq T_{\rm eff} \leq 6000$ K, gravities: $0.0 \leq \log g \leq 5.0$, metallicities: $-3.0 \leq$ [Fe/H] $\leq +0.5$ and [α/Fe] = 0.0.

Grid 3: The grid is computed in the wavelength range $\lambda\lambda$ 4500-6700 Å with effective temperatures $2700 \leq T_{\rm eff} \leq 7000$ K, gravities $0.0 \leq \log g \leq 5.0$, metallicities -3.0 $\leq$ [Fe/H] $\leq +0.3$ and [α/Fe] = 0.0, +0.2, +0.4 and +0.6

https://doi.org/10.1017/S0074180900204361 Published online by Cambridge University Press

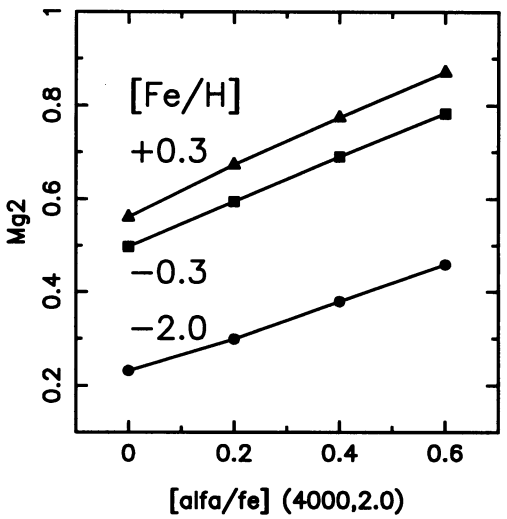

Figure 1. Mg_2 vs. $[\alpha/Fe]$ for $T_{\rm eff} = 4000$ K, $\log g = 2.0$

Grid 4: The use of a merging of grids 2 and 3 covering $\lambda\lambda$ 4500 – 10200 Å with the Bruzual & Charlot (1998, BC98) code for population synthesis is foreseen in the near future. The extension of this grid down to λ 3000 Å is also foreseeen, where sets of lines are already implemented.

4. Objectives

1. Derivation of stellar parameters: Use of the grid with a code for automatic comparison between the grid and observed spectra. The code Halo described in Cayrel et al. (1991), now improved, sets the radial velocity through cross-correlation, normalizes the observed spectrum for comparison with the grid synthetic spectra, and through a differences method derives the stellar parameters $T_{\rm eff}$, $\log g$, [Fe/H] and [Mg/Fe]. The grid is used in combination with an observed spectral library of reference stars in order to derive stellar parameters from low to medium resolution spectra of faint stars. The basis of the method was described in Cayrel et al. (1991), Perrin et al. (1995) and Meliani et al. (1995). The method has been applied to halo stars, Magellanic Clouds stars and bulge stars.

2. Indices: With measurement of indices, in particular the Lick indices, relations between them and stellar parameters are derived: index = f($T_{\rm eff}$, $\log g$, [Fe/H] and $[\alpha/Fe]$) (Barbuy et al. 1998). Through the build-up of Single Stellar Populations using isochrones coupled to the grid of synthetic spectra, indices for these SSP spectra are derived, and relations between the indices and SSP parameters [Fe/H] and $[\alpha/Fe]$ are established. In the near-infrared a redefinition of indices

https://doi.org/10.1017/S0074180900204361 Published online by Cambridge University Press

(such as the TiO_2 index - see Schiavon & Barbuy 1998), and the definition of new indices is necessary.

3. Population synthesis: The grid of synthetic spectra is being implemented in the code of evolutionary population synthesis by BC98. Grid 2 is already implemented, where the main advantage relative to other grids already in use in the BC98 code is the high resolution provided by our grid.

References

Allard, F., Hauschildt, P.H. 1995, ApJ, 445, 433

Baraffe, I., Chabrier, G., Allard, F., Hauschildt, P.H. 1995, ApJ, 446, L35

Barbuy, B. 1994, ApJ, 430, 218

Barbuy, B., Perrin, M.-N., Cayrel, R., Katz, D., van't Veer, C. 1998, in prep.

Bruzual, G., Charlot, S. 1998, in prep.

Burstein, D., Faber, S.M., Gaskell, C.M., Krumm, N. 1984, ApJ, 287, 56

Buzzoni, A., Gariboldi, G., Mantegazza, L. 1992, AJ, 103, 1814

Cayrel, R., Perrin, M.-N., Barbuy, B., Buser, R. 1991, A&A, 247, 108

Faber, S.M., Friel, E.D., Burstein, D., Gaskell, C.M. 1985, ApJS, 57, 711

Gorgas, J., Faber, S.M., Burstein, D., Gonzalez, J.J., Courteau, Stéphane, Prosser, C. 1993, ApJS, 85, 153

Grevesse, N., Noels, A., Sauval, J. 1996, in: ASP Conf. Ser. 99, (eds.) S.S. Holt & G. Sonneborn, p. 117

Gulati, R.K., Malagnini, M.L., Morossi, C. 1993, ApJ, 413, 166

Fuhr, J.R., Martin, G.A., Wiese, W.L. 1988, *Atomic Transition Probabilities: Iron through Nickel*, Journal of Physical and Chemical Reference Data, vol. 17, suppl. no. 4

Idiart, T., Freitas Pacheco, J.A., Costa, R.D.D. 1996, AJ, 111, 1169

Kurucz, R. 1992, in: *The stellar populations of galaxies*, IAU Symp. 149, (eds.) B. Barbuy & A. Renzini, Kluwer Acad. Press, p. 225

Martin, G.A., Fuhr, J.R., Wiese, W.L. 1988, *Atomic Transition Probabilities: Scandium through Manganese*, Journal of Physical and Chemical Reference Data, vol. 17, suppl. no. 3

Meliani, M.T., Barbuy, B., Perrin, M.-N. 1995, A&A, 300, 349

Perrin, M.-N., Friel, E.D., Bienaymé, O., Cayrel, R., Barbuy, B., Boulon, J. 1995, A&A, 298, 107

Plez, B., Brett, J.M., Nordlund, A. 1992, A&A, 256, 251

Schiavon, R.P., Barbuy, B. 1998, ApJ, in press

Trager, S.C., Worthey, G., Faber, S.M., Burstein, D., González, J.J. 1998, ApJS, 116, 1

Wiese, W.L., Martin, G.A., Fuhr, J.R. 1969, *Atomic Transition Probabilities: Sodium through Calcium*, Journal of Physical and Chemical Reference Data, NSRDS-NBS-22

Worthey, G., Faber, S.M., González, J.J., Burstein, D. 1994, ApJS, 94, 687