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Empirical calibration of the near-infrared Ca II triplet – II. The stellar atmospheric parameters

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ABSTRACT

We present a homogeneous set of stellar atmospheric parameters (T_{eff}, $\log g$, [Fe/H]) for a sample of about 700 field and cluster stars which constitute a new stellar library in the near-IR developed for stellar population synthesis in this spectral region (λ8350–9020). Having compiled the available atmospheric data in the literature for field stars, we have found systematic deviations between the atmospheric parameters from different bibliographic references. The Soubiran, Katz & Cayrel sample of stars with very well determined fundamental parameters has been taken as our standard reference system, and other papers have been calibrated and bootstrapped against it. The obtained transformations are provided in this paper. Once most of the data sets were on the same system, final parameters were derived by performing error weighted means. Atmospheric parameters for cluster stars have also been revised and updated according to recent metallicity scales and colour–temperature relations.

Key words: stars: abundances – stars: fundamental parameters – globular clusters: general – galaxies: stellar content.

1 INTRODUCTION

This paper is the second one in a series devoted to advance in the understanding of the stellar population properties of composite stellar systems by studying the strength of the integrated Ca triplet in the near-IR spectral range. As we have already explained in Paper I (Cenarro et al. 2001a), the main objectives of the series are to derive empirical fitting functions describing the behaviour of the Ca triplet index in terms of the stellar atmospheric parameters (Cenarro et al., Paper III, in preparation), and to perform stellar populations synthesis modelling in the near-IR spectral range (Vazdekis et al., Paper IV, in preparation). An ample stellar library covering a wide range of atmospheric parameters is necessary to obtain accurate fitting functions (Worthey et al. 1994, hereafter W94; Gorgas et al. 1999) and to derive reliable synthetic spectra for stellar populations of different ages and metallicities (Vazdekis 1999). Even so, this is not enough to ensure the quality of the empirical predictions, since they also depend on the accuracy of the input atmospheric parameters.

Recently, Gorgas et al. (1999) have shown how important an accurate, homogeneous set of input atmospheric parameters is when deriving empirical fitting functions. When calculating fitting functions for the λ4000 break, and after a thorough treatment of the errors, these authors show that the residuals from the derived functions are considerably larger than those just expected from measurement errors, indicating that the uncertainties in the input atmospheric parameters are the main source of random errors. Moreover, it is worth noting that, in order to obtain accurate fitting functions, not only a homogeneous but also a reliable set of atmospheric parameters is needed. Although a homogeneous set of parameters optimizes the scatter of the derived fitting functions, it does not guarantee that the zero-points of the adopted scales are absent of systematic errors. Therefore it is also important to choose an absolute scale as reliable as possible.

Up to date, most of the previous authors who had used stellar libraries to model the composite spectra of external galaxies (e.g. Díaz, Terlevich & Terlevich 1989; Gorgas et al. 1993, hereafter G93; W94; Jones 1997) have hardly tackled the already known problem of uncertainties in the atmospheric parameters and their implications on the final predictions of fitting functions. Instead of doing this, the usual approach has been to choose the parameters of the sample stars from the most recent bibliographic sources or to take the average values, without checking whether they were on a completely homogeneous system. As an example, it is common practice to use straight means from previous parameter compilations (like the one of Cayrel de Strobel et al. 1997), even

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though the individual analyses do not necessarily all have the same quality or are mutually independent. We refer the reader to the work of Soubiran, Katz & Cayrel (1998, hereafter SKC) for a thorough discussion of these and related problems. Furthermore, systematic deviations among different bibliographic sources may exist due to the different approaches for measuring atmospheric parameters.

In this paper we have derived a homogeneous set of stellar atmospheric parameters for the stellar library presented in Paper I. Section 2 introduces the working method and the atmospheric data compilation for the field stars. In Section 3 we present a calibration of the different bibliographic sources. The new atmospheric parameters for these stars are derived in Section 4, whereas in Section 5 we estimate the uncertainties in the final parameters. In addition, we have also revised the atmospheric parameters for the cluster stars in the library (Section 6). Finally, Section 7 is reserved for a discussion and summary.

Along this paper, the fundamental atmospheric parameters are considered, that is, effective temperature (T_{eff} in K), surface gravity ($\log g$ with g in $\mathrm{cm\,s^{-2}}$) and metallicity [$[\mathrm{Fe/H}] = \log(\mathrm{Fe/H}) - \log(\mathrm{Fe/H})_{\odot}$].

2 THE METHOD

The main goal of this paper is to obtain a new and homogeneous set of atmospheric parameters for the stars of the library introduced in Paper I. For this purpose, we have made a compilation of the three main atmospheric parameters of these stars in the literature. We selected one article of data, the reference source, which contained a large number of stars with parameters of high quality and bootstrapped all other sources against it, to end up with a homogeneous system of stellar atmospheric parameters. After this, the relative quality of all other data sources was determined by computing the rms deviation from the reference sample. Weighted according to the data quality, the various data sources were averaged to provide a final homogeneous set of atmospheric measurements.

The compilation includes 356 bibliographic sources, although not all of them were finally used to derive the final parameters. To start with, we included all the data from the catalogue of [Fe/H] determinations of Cayrel de Strobel et al. (1997), which contain parameters for more than 3000 stars from 700 sources up to 1995. After that, since not all our stars were included in the above catalogue, and to take into account more recent papers, we enlarged the compilation with 47 additional sources. Unavoidably, we could not include sources that were published during or after the last steps of this work (i.e. mid 1999). It must be noted that, even for stars with data in Cayrel de Strobel et al. (1997), we went back to the original data sources to exclude references that simply quote previous determinations.

To calculate systematic deviations, we had to select one standard source as a reference system. It was essential that this standard source contained a large number of stars including the three atmospheric parameters in a homogeneous way, and with a reasonably large parameter coverage. It is worthwhile to remark the latter since it is well known that a generic atmospheric parameter cannot be derived independently from the other two ones. Concerning the choice of a reference system, it is important to keep in mind that our final purpose is to obtain an empirical calibration of the behaviour of several line-strength indices as a function of atmospheric parameters. We are basically interested in ensuring that stars with very similar spectra have the same atmospheric parameters. This is the main reason why we have selected the paper of SKC as the initial standard source. It provides self-consistent atmospheric parameters for a total of 211 echelle spectra of cool stars ($4000 < T_{\mathrm{eff}} < 6300\,\mathrm{K}$) covering a wide range in gravity and metallicity. Making use of a reference spectral library (which includes stars with well-known atmospheric parameters) and input parameters for the target stars (weighted means of previous determinations from the literature), they followed an iterative method that takes into account spectral features comparisons, deriving revised values of effective temperature, gravity and metallicity for the sample of target stars. See full details of the above method in Katz et al. (1998). The final atmospheric parameters are, in the mean, consistent with the literature, and constitute a homogeneous set in the sense that similar spectra have similar parameters and the other way round.

Therefore, the atmospheric parameters from SKC will be our initial reference system. To obtain statistically significant comparisons between SKC and other sources, not only the 108 stars from SKC in common with our stellar library were included but also the rest of the stars in their catalogue. Obviously, these calibrations will only be valid for stars in the effective temperature range spanned by the sample of SKC, i.e. from 4000 to 6300 K. We did not follow a fully automatic approach and the original parameters for every star were checked for inconsistencies or outliers, removing original references when necessary.

3 CALIBRATION OF THE DIFFERENT SOURCES

Once the compilation was finished, we selected for each of the three atmospheric parameters those references that had at least 25 stars in common with the complete sample of SKC. That minimum number was chosen to ensure that comparisons between any source and SKC were statistically significant.

Let p and p_{ref} be the generic atmospheric parameters from any literature and the reference system (SKC in this first iteration), respectively. In order to calibrate this source on to the reference system we determined the following two types of fits and their significance level, α:

(i) A linear fit, $p = A + Bp_{\mathrm{ref}}$.
(ii) An offset, $p = A + p_{\mathrm{ref}}$.

We then tested whether the slope B was significantly different from one, using a t-test and a significance level of $\alpha = 0.1$. If that was the case, we adopted relation (i) to bootstrap the data from the source against the reference system [$p^* = (p - A)/B$, where p^* is the corrected parameter]. If it was not significant, we used the same procedure to test the significance of the offset term A in relation (ii) and applied that correction if necessary ($p^* = p - A$). Obviously, the original parameters were kept when this term was not statistically different from zero ($p^* = p$).

The procedure detailed above leads to a set of corrected parameters which were used to calculate the final parameters of a large number of stars not included in SKC. These stars constitute a new reference set of stars (hereafter RF1), with parameters in the same system as SKC. In order to calibrate all those reference sources which did not have enough stars in common with SKC, the whole process was repeated using SKC and RF1 together as the reference samples. Since the number of stars in the remaining sources is generally rather small, the minimum number of stars in common required to calibrate a reference was decreased to 15. In this way, we derived a second set of final parameters which is called RF2. We did not perform further iterations since, after the second one, those sources that had not been calibrated yet did not possess enough stars in common with the reference systems (SKC, RF1 and RF2) to ensure reliable calibrations.

In Tables 1, 2 and 3 we present respectively, the details of the calibrations on effective temperature, gravity and metallicity for all the calibrated sources. Reference codes are explained in Table 4. To illustrate the procedure, in Fig. 1, we show some representative calibrations for each atmospheric parameter and the kind of correction that was applied. In the above tables we include a code to indicate the different methods used to derive the original atmospheric parameters in each paper. Note that, although the tabulated standard deviations are because of the uncertainties both in the SKC parameters and in the calibrated reference, a relative comparison of the different values can provide an estimate of the reliability of the different methods. Even though a critical analysis of these techniques is out of the scope of this paper, it must be noted that we do not find any systematic trend when comparing the uncertainties (σ) or the calibration parameters (A, B) of the different working methods.

4 ATMOSPHERIC PARAMETERS FOR FIELD STARS

The new set of atmospheric parameters of the stellar library presented in this paper has been derived in different ways depending on the original literature sources that were available. Table 5 lists the final derived atmospheric parameters for the field stars of the library. In Table 6 we present a brief explanation of the different methods and the codes we have used to identify them. A more detailed description is the following:

Table 1. Calibrations of bibliographic sources to convert their effective temperatures on to the reference system. Columns are: Reference code (see Table 4), method used to derive temperatures, number of stars in common with the standard source, applied correction (s: straight line; o: offset; n: none), standard source (1: SKC; 2: SKC & RF1), rms standard deviation from the fit, independent term, slope, and range of the fit. Codes for the methods: (a) IR flux method, (b) spectroscopic methods, and (c) from colour relations. Values from JON and WOR only include original determinations, that is, parameters taken from other sources were not employed (this also holds for Tables 2 and 3).

Code	M	N	Fit	S	σ	A	B	$T_{\rm eff}$
AAM	a	67	n	1	98.	0.0	1.0	4300, 6400
AFG	b	30	n	1	124.	0.0	1.0	5600, 6400
BAL	c	21	n	2	100.	0.0	1.0	6000, 6400
BLL	a	44	s	2	75.	−175.5	1.0440	3900, 6400
BSL	c	39	s	1	66.	396.5	0.9118	4000, 5100
CLL	c	40	n	1	76.	0.0	1.0	4600, 6300
EAG	c	36	o	1	60.	39.9	1.0	5650, 6350
GCC	c	65	s	1	86.	−178.8	1.0397	4100, 6500
GRJ	b	28	s	2	115.	835.8	0.8637	5100, 6300
GRS	c	25	n	1	116.	0.0	1.0	3800, 6100
HEA	c	26	s	2	65.	811.0	0.8529	5100, 6200
JON	c	47	s	2	67.	−291.4	1.0604	4200, 5300
LAI	c	53	o	2	71.	−51.1	1.0	4700, 6400
LCH	c	38	o	2	62.	−72.9	1.0	3900, 5000
MAS	c	38	s	1	83.	2852.0	0.5450	5900, 6300
MCW	c	62	n	1	86.	0.0	1.0	3900, 5900
NHS	c	22	n	2	96.	0.0	1.0	4700, 6300
PET	c	26	o	2	106.	−83.7	1.0	4500, 6400
PSB	c	26	s	1	101.	517.7	0.9042	4300, 6000
PSK	bc	26	s	2	100.	−404.6	1.0910	4200, 5300
RMB	bc	25	o	2	80.	−77.1	1.0	5200, 6150
SIC	b	20	s	2	112.	−661.1	1.1006	4200, 6300
TAY	abc	62	s	1	92.	1075.9	0.8166	4800, 6200
TLL	c	22	o	2	82.	−67.5	1.0	4700, 6300
WOR	c	44	n	1	74.	0.0	1.0	4100, 6100

Table 2. Calibrations of bibliographic sources to convert their surface gravities on to the reference system. Columns are the same as in Table 1. Methods employed to derive gravities: (a) spectroscopic method, (b) physical method (parallaxes), (c) physical method (luminosities from photometric indices), (d) physical method (luminosities from Ca K line), (e) photometric, and (f) other.

Code	M	N	Fit	S	σ	A	B	$\log g$
AFG	a	30	n	1	0.27	0.0	1.0	2.5, 4.8
BAL	c	23	n	2	0.07	2.560	0.391	3.9, 4.3
BSL	cd	39	n	1	0.19	0.0	1.0	1.4, 3.9
EAG	f	36	o	1	0.12	0.042	1.0	3.9, 4.6
GCC	a	65	s	1	0.24	−0.200	1.077	0.0, 5.2
GRS	b	24	o	1	0.30	0.139	1.0	0.7, 4.5
HEA	b	23	n	2	0.18	0.0	1.0	3.8, 4.6
KNK	e	28	o	1	0.14	0.075	1.0	4.0, 4.7
LAI	ab	48	s	2	0.32	2.038	0.520	3.4, 4.6
LBO	a	16	n	2	0.39	0.0	1.0	0.0, 4.0
LCH	ad	38	o	2	0.37	−0.527	1.0	0.2, 2.8
MAS	e	38	o	1	0.40	0.247	1.0	3.8, 5.0
MCW	bd	62	o	1	0.21	0.233	1.0	1.6, 4.2
NHS	b	18	s	2	0.25	1.740	0.609	3.7, 4.7
PSK	cf	25	n	2	0.25	0.0	1.0	0.2, 3.0
TLL	a	22	s	2	0.21	−0.910	1.210	2.5, 5.1
WOR	f	34	n	1	0.33	0.0	1.0	1.0, 4.8

Table 3. Calibrations of bibliographic sources to convert their metallicities on to the reference system. Columns are the same as in Table 1. Methods employed to compute metallicities: (a) high-resolution (<0.5 Å) spectroscopy, (b) mid-resolution (> 0.5 Å) spectroscopy, (c) photometry, and (d) spectrophotometry.

Code	M	N	Fit	S	σ	A	B	[Fe/H]
AAM	ac	68	s	1	0.22	−0.006	1.065	−3.0, +0.4
AFG	a	30	s	1	0.13	−0.120	0.858	−2.5, −0.4
BAL	a	23	o	2	0.10	−0.067	1.0	−0.7, +0.3
BKP	b	27	s	1	0.21	−0.324	0.829	−3.1, −1.0
BSL	a	39	n	1	0.19	0.0	1.0	−0.8, +0.5
CGC	a	27	o	2	0.10	0.129	1.0	−2.4, −1.0
CLL	a	41	s	1	0.10	0.029	1.070	−2.7, +0.2
EAG	a	36	s	1	0.05	−0.047	0.925	−1.1, +0.2
GCC	a	65	s	1	0.10	−0.002	0.947	−3.0, +0.2
GRS	a	25	n	1	0.18	0.0	1.0	−2.4, +0.2
HEA	a	23	o	2	0.18	−0.066	1.0	−1.1, +0.4
JON	d	49	o	2	0.13	0.056	1.0	−0.5, +0.3
KNK	c	32	s	1	0.09	−0.036	0.911	−2.1, +0.2
LAI	b	51	o	2	0.16	−0.051	1.0	−2.5, +0.5
LBO	a	24	o	2	0.12	0.093	1.0	−2.7, −0.6
LCH	a	35	s	2	0.15	−0.058	0.665	−0.5, +0.2
LUB	a	22	s	2	0.12	−0.016	0.945	−2.8, −0.6
MAS	c	39	s	1	0.12	−0.040	0.630	−1.0, +0.2
MCW	a	62	o	1	0.09	−0.062	1.0	−0.7, +0.2
NHS	c	22	s	2	0.13	−0.089	0.885	−2.5, −1.0
PET	a	26	s	2	0.12	0.014	1.058	−3.5, −0.5
PSB	a	26	n	1	0.11	0.0	1.0	−3.2, −0.7
PSK	a	29	o	2	0.14	−0.033	1.0	−3.1, −0.9
RMB	a	25	o	2	0.16	−0.064	1.0	−2.5, −0.7
SIC	ab	19	n	2	0.15	0.0	1.0	−1.8, +0.5
THE	a	12	n	1	0.13	0.0	1.0	−2.9, +0.4
TLL	a	22	o	2	0.09	−0.114	1.0	−2.7, −1.3
WOR	a	76	o	2	0.14	0.033	1.0	−2.6, +0.5
WAL	b	28	s	2	0.19	0.055	0.873	−2.0, +0.4
ZAS	c	46	s	2	0.12	−0.063	0.608	−0.6, +0.1

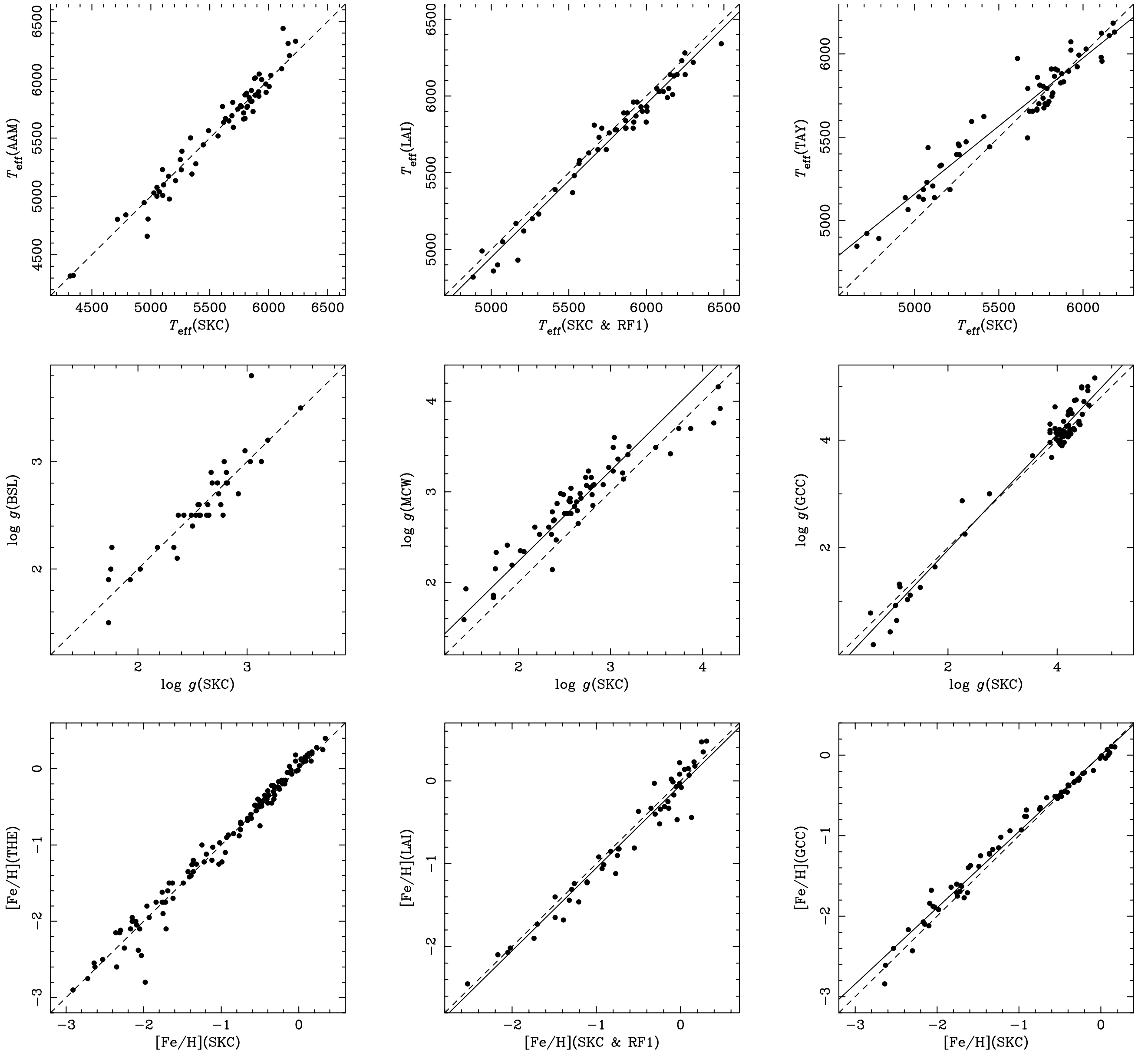

Figure 1. Calibrations on to the reference system (SKC or SKC & RF1). The upper three panels show representative cases of null, offset and linear corrections for sources giving effective temperatures. A dashed line show the expected behaviour when no systematic deviation exists, whereas the solid line is the applied correction. The same is done for sources publishing surface gravities and metallicities in the centred and lower panels respectively. Points deviating more than 3σ from an initial fit were not used to derive the final calibration. More details about these and other calibrations are presented in Tables 1–3.

(i) If the star is included in the sample of SKC, the three atmospheric parameters from that paper were kept (coded SKC). This was the case for a total of 108 stars of our sample.

(ii) When the star is not included in the sample of SKC but in N previously calibrated sources, and the original parameters are within the calibration ranges listed in Tables 1–3, the new parameters P were determined by taking the weighted average:

$$P = \frac{\sum_{i=1}^{N} p_i^*/\sigma_i^2}{\sum_{i=1}^{N} 1/\sigma_i^2} \tag{1}$$

where p_i^* is the corrected parameter and σ_i corresponds to the rms standard deviation of the comparison with the reference system (SKC, or SKC & RF1) (listed in Tables 1–3). Most (about 60 per cent, see below) of the atmospheric parameters of the stellar library presented here have been derived in this way (coded RF1 and RF2). Note that this procedure was only carried out when the atmospheric parameter of the star was within the range of calibration, that is, extrapolations from the fits have never been applied.

(iii) When the star is not included in any calibrated source (or, if included, the atmospheric parameters are out of the calibration range), the final parameter is the raw mean value from all the available original sources and no previous correction to the parameter value has been applied. Obviously, these final parameters should be less reliable than those obtained from calibrated sources. Since the scatter of effective temperatures from different sources is different for hot and cold stars than for intermediate temperature stars, we divided the stars from non-calibrated sources into three groups: stars of intermediate temperatures, $4000 < T_{\rm eff} < 6300$ K (coded RF3), hot stars with $T_{\rm eff} > 6300$ K (coded RF4) and cold stars with $T_{\rm eff} < 4000$ K (coded RF5). This will allow us to derive a more accurate temperature uncertainty for each one of the three new categories.

Table 4. Codes for calibrated original references.

Code	Reference
AAM	Alonso, Arribas & Martínez-Roger (1996a)
AFG	Axer, Fuhrmann & Geheren (1994)
BAL	Balachandran (1990)
BKP	Beers et al. (1990)
BLL	Blackwell & Lynas-Gray (1994)
BSL	Brown et al. (1989)
CGC	Carretta et al. (2000)
CLL	Carney et al. (1994)
EAG	Edvardsson et al. (1993)
GCC	Gratton, Carretta & Castelli (1996)
GRJ	Gray & Johanson (1991)
GRS	Gratton & Sneden (1987)
HEA	Hearnshaw (1974)
JON	Jones (1997)
KNK	Kunzli et al. (1997)
LAI	Laird (1985)
LBO	Luck & Bond (1985)
LCH	Luck & Challener (1995)
LUB	Luck & Bond (1983)
MAS	Marsakov & Shevelev (1995)
MCW	McWilliam (1990)
NHS	Nissen, Hoeg & Schuster (1997)
PET	Peterson (1981)
PSB	Pilachowski, Sneden & Booth (1993)
PSK	Pilachowski, Sneden & Kraft (1996)
RMB	Rebolo, Molaro & Beckman (1988)
SIC	Silva & Cornell (1992)
TAY	Taylor (1994)
THE	Thévenin (1998)
TLL	Tomkin et al. (1992)
WAL	Wallerstein (1962)
WOR	Worthey et al. (1994)
ZAS	Zakhozhaj & Shaparenko (1996)

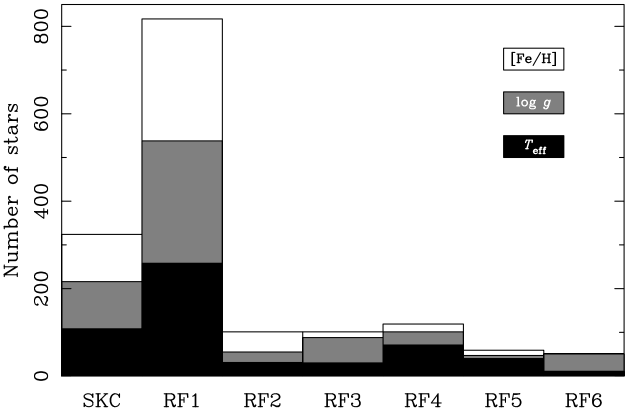

Figure 2. Histogram illustrating the total number of stars with effective temperature (black bars), gravity (grey bars) and metallicity (white bars) in each category.

(iv) If there is no data in the literature, both the effective temperature and surface gravity are estimated from the spectral type and the luminosity class using the tabulated atmospheric data from Lang (1991). Only a few parameters (2 per cent of the temperature estimations and 7 per cent for gravities) were derived in this way, which we coded as RF6.

To summarize, Fig. 2 illustrates the number of stars with final atmospheric parameters in each different category. A total of 549 temperatures, 547 gravities and 476 metallicities were derived for the 550 field stars of the stellar library. RF1 is clearly the most populated category, including about half of the final atmospheric parameters. Moreover, it is worth noting that most of the effective temperatures (72.3 per cent), gravities (75.3 per cent) and metallicities (91.0 per cent) were taken from the initial reference system (SKC), or derived from calibrated and corrected original sources (RF1 and RF2).

A detailed table containing all the original data which were used to derive the final atmospheric parameters of the stellar library is available from: http://www.ucm.es/info/Astrof/ellipt/CATRIPLET.html and http://www.nottingham.ac.uk/~ppzrfp/CATRIPLET.html.

5 UNCERTAINTY ESTIMATES IN THE DERIVED PARAMETERS

In this section, we calculate mean error estimates for the final atmospheric parameters of the library stars.

In general, the number of original atmospheric parameters for a single star is not large enough to estimate a reliable individual error. This is the reason why we present an uncertainty estimate for each one of the categories defined in Section 4 by calculating a mean rms standard deviation of all those stars whose final parameters were derived from two or more original sources. Since categories RF1 and RF2 were derived from corrected atmospheric parameters in a homogeneous way, it is expected that their uncertainties are very similar. Therefore, we estimate a more reliable error for both samples together by using all the stars in RF1 and RF2. If P_k is the final parameter of the kth star derived from N_k corrected parameters $\overset{*}{p}_{i,k}$, and $\sigma_{i,k}$ is the rms standard deviation of the fit used to calculate each corrected parameter, then the unbiased rms standard deviation σ of both categories is derived as follows:

$$\sigma = \sqrt{\frac{\left(\sum_{k=1}^{N_{\rm star}} N_k\right)\left[\sum_{k=1}^{N_{\rm star}}\sum_{i=1}^{N_k}(\overset{*}{p}_{i,k}-P_k)^2/\sigma^2_{i,k}\right]}{\left[\sum_{k=1}^{N_{\rm star}}(N_k-1)\right]\left(\sum_{k=1}^{N_{\rm star}}\sum_{i=1}^{N_k}1/\sigma^2_{i,k}\right)}} \qquad (2)$$

where $N_{\rm star}$ is the total number of stars with at least two original sources which were used to derive the final atmospheric parameter.

Categories RF3, RF4 and RF5 consist of stars in different temperature ranges, and we have estimated errors for each one of them separately. The method is the same for the three samples. Using the same notation and requirements given above and considering non-corrected original parameters $p_{i,k}$, the mean rms standard deviation for each category can be given by:

$$\sigma = \sqrt{\frac{\sum_{k=1}^{N_{\rm star}}\sum_{i=1}^{N_k}(p_{i,k}-P_k)^2}{\sum_{k=1}^{N_{\rm star}}(N_k-1)}}. \qquad (3)$$

It is clear that errors for those categories which were defined from a single source, namely SKC and RF6, could not be calculated in this way. However, an error estimation for SKC data is published in the original paper. They adopt 100 K, 0.5, and 0.3 dex respectively, for $T_{\rm eff}$, $\log g$ and [Fe/H] as an upper limit for the scatter inherent to their method.

In summary, Table 7 shows the uncertainty estimates obtained for the rest of categories.

6 ATMOSPHERIC PARAMETERS FOR CLUSTER STARS

The stellar library presented in this series of papers is an extension of the Lick/IDS (Image Dissector Scanner) stellar sample (G93; W94). This library included a large number of (open and globular) cluster stars which have been retained in the present version. In this section we revise the atmospheric parameters of these cluster stars. The final adopted parameters are presented in Table 8.

Table 5. Final atmospheric parameters of the field stars. References for atmospheric parameters: SKC from Soubiran et al. (1998). Numerical references *ijk* indicate that $T_{\rm eff}$ is from RF*i*, log *g* from RF*j* and [Fe/H] from RF*k* (see Table 6). Sources for spectral types are the Bright Star Catalog (Hoffleit & Jaschek 1982), Andrillat, Jaschek & Jaschek (1995), Gorgas et al. (1999), the Hipparcos Input Catalog and the Simbad database at http://simbad.u-strasbg.fr/Simbad.

HD/Other	SpT	$T_{\rm eff}$	log *g*	[Fe/H]	Ref
108	06 f pec	38367	3.68		44
249	K1 IV	4723	2.40	−0.32	232
417	K0 III	4825	2.40	−0.32	232
1461	G0 V	5816	4.30	0.20	131
1918	G9 III	4863	2.01	−0.53	232
2665	G5 IIIwe	5013	2.35	−1.96	SKC
2857	A2 (HB)	7563	2.67	−1.60	441
3443	K1 V+…	5335	4.57	−0.14	131
3546	G5 III	4942	2.73	−0.66	SKC
3567	F5 V	5917	3.96	−1.32	SKC
3651	K0 V	5417	4.63	0.01	122
4307	G0 V	5742	4.07	−0.25	111
4614	G0 V	5848	4.40	−0.27	SKC
4628	K2 V	4960	4.60	−0.29	SKC
4656	K5 III	3915	1.45	−0.14	111
5395	G8 III-IV	4797	2.55	−0.70	SKC
6186	G9 III	4857	2.67	−0.33	111
6203	K0 III-IV	4492	2.60	−0.29	111
6474	G4 Ia	6241	1.55	0.25	111
6695	A3 V	8390	4.30		41
6755	F8 V	5102	2.40	−1.41	SKC
6833	G8 III	4380	1.25	−0.99	SKC
6860	M0 III	3845	1.57	0.10	255
6903	G0 III	5570	2.9		36
7010	K0 IV	5000	3.3		66
7927	F0 Ia	7425	0.70		44
8424	A0 Vnn	8455	4.10		41
9826	F8 V	6135	4.08	0.11	111
10307	G2 V	5847	4.28	0.02	111
10380	K3 III	4057	1.43	−0.25	SKC
10476	K1 V	5150	4.44	−0.17	SKC
10700	G8 V	5264	4.36	−0.50	SKC
10780	K0 V	5393	4.60	0.43	122
10975	K0 III	4788	2.40	−0.30	232
11004	F7 V	4841	2.5		16
12014	K0 Ib	5173	2.35	0.45	111
12533	K3 IIb	4383	0.92	−0.23	333
12929	K2 III	4458	2.24	−0.18	111
13043	G2 V	5695	3.68	0.10	111
13161	A5 III	8100	3.1		66
13267	B5 Ia	13800	2.4		46
13611	G8 Iab	5040	2.59	−0.23	111
13783	G8 V	5338	4.35	−0.55	SKC
13974	G0 V	5700	4.42	−0.33	SKC
14134	B3 Ia	15150	2.6		46
14662	F7 Ib	5900	1.35	−0.03	333
14802	G1 V	5629	3.59	−0.08	111
14938	F5	6132	4.03	−0.34	111
15596	G5 III-IV	4755	2.50	−0.70	SKC
16160	K3 V	4718	4.50	−0.07	131
16901	G0 Ib-II	5478	1.0	0.00	331
17378	A5 Ia	8580	1.35		41
17491	M4 III	3565	0.6		55
17548	F8	5944	4.28	−0.59	111
17709	K5 III	3894	1.14	−0.25	111
18191	M6 III	3289	0.3		55
18391	G0 Ia	5500	0.00	−0.28	331
19373	G0 V	5989	4.19	0.16	131
19445	A4p	5918	4.35	−2.05	SKC
19476	K0 III	4852	2.92	0.10	SKC
20041	A0 Ia	9480	2.13		41
20630	G5 V	5576	4.41	0.03	131
20893	K3 III	4340	2.03	0.08	111
22049	K2 V	5052	4.57	−0.15	SKC
22484	F8 V	5933	4.03	−0.09	111
22879	F9 V	5808	4.29	−0.83	111
23249	K0 IV	4884	3.40	−0.11	111
23439 A	K1 V	5118	4.50	−1.02	SKC
23439 B	K2 V	4792	4.65	−1.02	111
23841	K1 III	4500	1.30	−0.95	331
24451	K4 V	4357	4.61		11
25329	K1 Vsb	4787	4.58	−1.72	SKC
26297	G5-6 IVw	4316	1.06	−1.67	SKC
26462	F4 V	6814	4.12	0.10	412
26690	F3 V	6925	3.96	0.08	411
26965	K1 V	5073	4.19	−0.31	SKC
27295	B9 IV	11677	3.93	−0.73	444
27371	K0 III	4961	2.71	0.07	111
27697	K0 III	4966	2.76	0.17	111
28305	G9.5 III	4844	2.68	0.11	111
28307	K0 III	4981	2.87	0.10	111
30455	G2 V	5685	4.45	−0.36	112
30649	G1 V-VI	5693	4.23	−0.50	111
30652	F6 V	6482	4.35	0.05	111
30743	F3-5 V	6395	4.12	−0.33	111
34334	K3 III	4211	1.96	−0.40	111
34411	G0 V	5835	4.17	0.06	SKC
35369	G8 III	4863	2.50	−0.26	SKC
35601	M1.5 Ia	3550	0.00	−0.20	661
35620	K4 IIIp	4367	1.75	−0.03	SKC
36003	K5 V	4464	4.61	0.09	113
36079	G5 II	5170	2.04	−0.38	111
36162	A3 Vn	8260	4.28		41
37160	G8 III-IV	4668	2.46	−0.50	SKC
38393	F6 V	6302	4.26	−0.05	111
38656	G8 III	4927	2.52	−0.22	111
38751	G8 III	4748	2.27	0.04	111
39587	G0 V	5869	4.45	−0.01	111
39801	M2 Iab	3614	0.00		55
39970	A0 Ia	9400	1.43		41
41117	B2 Iave	17482	2.70		41
41597	G8 III	4700	2.38	−0.54	SKC
41636	G9 III	4708	2.50	−0.20	111
41692	B5 IV	14411	3.12	−0.40	444
42475	M1 Iab	4000	0.70	−0.36	665
43318	F6 V	6212	3.93	−0.14	111
44007	G5 IVw	4969	2.26	−1.47	SKC
45282	G0	5348	3.24	−1.44	SKC
46687	C II	2831		0.20	5 5
46703	F7 IVw	6000	0.4	−1.70	333
47205	K1 IV	4753	2.93	0.05	111
47914	K5 III	3976	1.49	0.05	111
48433	K1 III	4460	1.88	−0.25	SKC
48682	G0 V	5946	4.07	0.05	111
49161	K4 III	4180	1.46	0.08	111
49293	K0 III	4629	2.16	−0.02	111
50778	K4 III	4009	1.60	−0.27	111
51440	K2 III	4402	2.28	−0.35	111
52005	K4 Iab	4116	0.20	−0.20	121
52973	G0 Ib var	5727	1.63	0.34	333

6.1 Metallicity scale

Although the cluster metallicities adopted in G93 were chosen as the most reliable estimates at that time, a revision can provide more accurate values. The updated metallicities, together with Lick/IDS values, are listed in Table 9.

The [Fe/H] values for globular cluster stars that were adopted in the Lick/IDS system, taken from several sources (see references in the original papers), are basically in the Zinn & West (1984,

Table 5 – *continued*

HD/Other	SpT	$T_{\rm eff}$	log g	[Fe/H]	Ref
54300	Spe	2700			5
54716	K4 Iab	4018	1.62	−0.16	111
54719	K2 III	4367	1.77	0.08	111
54810	K0 III	4697	2.35	−0.33	112
55575	G0 V	5905	4.39	−0.28	111
57060	07 Ia	35950	3.2		46
57061	09 Ib	32300	3.0		46
57118	F0 Ia	7700	1.7		66
57264	G8 III	4620	2.72	−0.33	111
58207	K0 III	4786	2.55	−0.11	111
58551	F6 V	6145	4.18	−0.55	111
58972	K3 III	4031	1.81	−0.28	111
59612	A5 Ib	8100	1.45	0.08	444
60179	A1 V	10286	4.0	0.48	444
60522	M0 III-IIIb	3854	1.20	0.12	111
61603	K5 III	3809	1.50	0.24	111
61913	M3 II-III	3530	0.70		66
61935	K0 III	4779	2.50	−0.06	111
62345	G8 IIIa	5015	2.63	−0.08	111
62721	K5 III	3960	1.51	−0.22	111
63302	K3 Iab	4500	0.2	0.12	331
63352	K0 III	4226	2.20	−0.31	111
63700	G6 Ia	4990	1.15	0.24	333
64606	G8 V	5210	4.24	−0.97	SKC
65583	G8 V	5262	4.45	−0.56	131
65714	G8 III	4840	1.50	0.27	111
66141	K2 III	4258	1.90	−0.30	111
69267	K4 III	4037	1.51	−0.11	111
69897	F6 V	6250	4.24	−0.24	111
70272	K5 III	3897	1.28	0.04	111
72184	K2 III	4627	2.61	0.12	111
72324	G9 III	4885	2.13	0.16	111
72905	G1.5 Vb	5853	4.48	−0.08	111
73394	G5 IIIw	4500	1.10	−1.38	321
73471	K2 III	4488	2.00	0.11	111
73593	G8 IV	4717	2.25	−0.15	112
73665	K0 III	4964	2.35	0.13	112
73710	K0 III	4930	2.33	0.28	111
74000	F6 VI	6197	4.39	−2.02	111
74377	K3 V	4912	4.63	−0.07	113
74395	G2 Iab	5250	1.3	−0.05	331
74442	K0 III	4657	2.51	−0.06	111
74462	G5 IV	4527	1.53	−1.40	111
75732	G8 V	5079	4.48	0.16	SKC
76932	F7-8 IV-V	5866	3.96	−0.93	SKC
78418	G5 IV-V	5679	4.2	−0.12	131
79211	M0 V	3769	4.71	−0.40	515
81797	K3 II-III	4120	1.54	−0.06	111
82210	G4 III-IV	5208	3.19	−0.28	111
82328	F6 IV	6311	3.90	−0.17	111
82885	G8 IV−V	5487	4.61	0.07	122
83618	K3 III	4231	1.74	−0.08	111
84441	G1 II	5310	1.81	−0.13	111
84737	G2V	5874	4.07	0.08	SKC
84937	F5 VI	6228	4.01	−2.17	SKC
85503	K0 III	4472	2.33	0.23	SKC
86728	G1 V	5742	4.21	0.13	SKC
87140	K0	5099	2.76	−1.70	SKC
87737	A0 Ib	9959	1.98	0.02	444
88230	K7 V	3861	4.68	−0.93	111
88284	K0 III	4937	2.86	0.15	111
88609	G5 IIIwe	4513	1.26	−2.64	SKC
89010	G2 IV	5692	3.92	0.01	111
89025	F0 III	7083	3.2		46
89449	F6 IV	6333	4.06	0.21	111
90508	G1 V	5787	4.40	−0.21	SKC
93487	F8	5250	1.80	−1.05	321
94028	F4 V	5941	4.21	−1.49	SKC
94247	K3 III	4221	2.17	−0.16	111
94705	M5.5 III	3330	0.20		52
95128	G0 V	5834	4.34	0.04	111
95272	K0 III	4637	2.33	−0.05	111
97907	K3 III	4350	2.07	−0.10	111
98230/1	G0 V	5831	4.46	−0.34	333
101501	G8 V	5388	4.60	−0.13	111
102224	K0 III	4383	2.02	−0.46	SKC
102328	K3 III	4395	2.09	0.35	111
102634	F7 V	6337	4.12	0.28	111
102870	F8 V	6109	4.20	0.17	SKC
103095	G8 Vp	5025	4.56	−1.36	SKC
103736	G8 III	4900	2.3		66
103799	F6 V	6174	3.85	−0.48	111
103877	Am	7306	4.0	0.40	441
104985	G9 III	4667	2.20	−0.37	232
105546	G2 IIIw	5228	2.50	−1.50	221
106516	F5 V	6153	4.36	−0.73	111
107213	F8 Vs	6302	4.01	0.29	111
107328	K0 IIIb	4444	2.20	−0.33	111
107752	G5	4625	0.80	−2.74	121
107950	G6III	5092	2.28	−0.11	111
108177	F5 VI	6067	4.25	−1.70	111
108317	G0	5083	2.58	−2.36	SKC
109995	A0 V (HB)	8034	2.98	−1.55	444
110184	G5	4380	0.63	−2.30	SKC
110411	A0 V	8970	4.36	−1.00	444
110897	G0 V	5830	4.23	−0.48	SKC
111721	G6 V	5014	3.22	−1.21	111
112014	A0 V	9520	4.1		66
112028	A1 III	9480	3.3		66
112412	F0 V	6462	4.10	−0.11	411
112413	A0 spe	9944	3.85	0.32	444
112989	G9 III	4693	2.61	0.20	111
113092	K2 III	4280	1.94	−0.70	111
113139	F2 V	6810	3.87	0.22	411
113226	G8 IIIvar	4983	2.80	0.05	SKC
113285	M8 III	2924	0.00		51
113848	F4 V	6593	3.83	−0.16	411
114710	G0 V	5975	4.40	0.09	SKC
114762	F9 V	5812	4.12	−0.75	SKC
114946	G6 V	5171	3.64	0.13	111
114961	M7 III	3014	0.00	−0.84	512
115043	G1 V	5923	4.40	−0.07	111
115444	K0	4736	1.70	−2.71	121
115604	F3 III	7200	3.0	0.33	441
115617	G6 V	5536	4.36	−0.01	111
116114	Ap	8040	4.17	0.48	441
116842	A5 V	8051	4.33		44
117176	G5 V	5525	3.39	−0.07	122
118055	K0 IIIw	4089	0.45	−1.92	111
120136	F7 V	6304	4.15	0.27	211
120452	K0.5 III-IIIb	4783	2.59	0.03	111
120933	K5 III	3820	1.29	0.56	111
121146	K2 IV	4403	3.00	−0.12	111
121370	G0 IV	6003	3.62	0.25	111
121447	K4 III	4200	0.8	−0.05	331
122563	F8 IV	4566	1.12	−2.63	SKC

hereafter ZW84) metallicity scale. This scale is based on a compilation of metallicities from several parameters (mainly the photometric index Q_{39}) tied to a high-resolution scale using relatively old echelle spectra. In the last years, and from high-quality high-dispersion spectra and improved model atmospheres, several authors (Carretta & Gratton 1997, hereafter CG97; see also Rutledge, Hesser & Stetson 1997) have derived a new homogeneous [Fe/H] scale which shows significant deviations from the ZW84 scale. Although at this time no consensus exists about which scale is more reliable, in this work we have decided to adopt the new scale from CG97 for the following reasons: (i) Rutledge et al. (1997) have shown that their near-IR Ca index (W'), the calibration

Table 5 – *continued*

HD/Other	SpT	T_{eff}	$\log g$	[Fe/H]	Ref
122956	G6 IV-Vw	4635	1.49	−1.75	SKC
123299	A0 III	10080	3.30	−0.56	444
123657	M4 III	3452	0.6	0.00	562
124186	K4 III	4346	2.10	0.24	111
124547	K3 III	4130	1.81	0.23	111
124850	F7 IV	6135	3.83	−0.10	111
124897	K2 IIIp	4361	1.93	−0.53	SKC
125454	G9 III	4797	2.58	−0.15	111
125560	K3 III	4381	2.06	0.08	111
126327	M7.5 III	3000	0.00	−0.61	512
126660	F7 V	6227	3.84	−0.27	111
126681	G3 V	5565	4.78	−1.29	111
127243	G3 IV	4978	3.20	−0.59	SKC
127665	K3 III	4259	1.83	−0.09	111
127762	A7 III	7840	3.2		46
128167	F2 V	6721	4.38	−0.39	111
129312	G8 III	4880	2.45	−0.06	111
130109	A0 V	9820	4.35		44
130694	K4 III	4040	1.62	−0.28	111
130705	K4 II-III	4335	2.10	0.41	111
131918	K4 III	3970	1.49	0.28	111
131976	M1 V	3506	4.73		51
131977	K4 V	4533	4.79	0.02	131
132142	K1 V	5108	4.50	−0.55	SKC
132345	K3 III-IVp	4374	1.60	0.42	112
132475	F6 V	5599	3.50	−1.66	121
132933	M0.5 IIb	3660	0.7		56
134063	G5 III	4881	2.34	−0.66	232
134083	F5 V	6575	4.32	0.00	111
134169	G1 Vw	5798	3.87	−0.91	SKC
134439	K0 V	4940	4.85	−1.49	121
134440	K3 V-VI	4742	4.67	−1.47	131
135148	K0	4289	0.19	−1.96	211
135722	G8 III	4847	2.56	−0.44	SKC
136028	K5 III	3995	1.90	0.19	111
136202	F8 III-IV	6082	3.84	−0.08	122
136479	K1 III	4722	2.56	0.14	111
136726	K4 III	4156	1.91	0.14	111
137391	F0 V	7190	4.14	0.28	444
137471	M1 III	3810	1.10		51
137759	K2 III	4498	2.38	0.05	111
138279	F5	5997	2.50	−1.67	331
138481	K5 III	3890	1.41	0.26	111
139669	K5 III	3917	1.41	−0.01	111
140283	F3 VI	5687	3.55	−2.53	SKC
140573	K2 III	4528	2.43	0.17	111
141004	G0 Vvar	5915	4.10	−0.01	SKC
141144	K0 III	4750	2.1		66
141680	G8 III	4730	2.52	−0.21	111
141714	G3.5 III	5230	3.02	−0.28	111
142091	K0 III-IV	4796	3.22	0.00	111
142373	F9 V	5821	4.13	−0.41	SKC
142860	F6 V	6249	4.16	−0.15	111
142980	K1 IV	4549	2.74	0.11	111
143107	K3 III	4337	1.95	−0.22	111
143761	G2 V	5762	4.23	−0.20	SKC
144585	G5 V	5791	3.95	0.29	111
144872	K3 V	4739	4.65	−0.31	112
145148	K0 IV	4849	3.45	0.10	112
145328	K0 III	4683	3.02	−0.18	111
145675	K0 V	5264	4.66	0.34	SKC
146051	M0.5 III	3847	1.4	0.32	255
147379 A	M0 V	3720	4.67	−1.40	511
147379 B	M3 V	3247	4.84		51
147677	K0 III	4923	2.71	−0.01	111
148513	K4 IIIp	4014	1.67	0.11	111
148743	A7 Ib	7100	1.60	−0.15	441
148783	M6 III	3244	0.2	0.02	555
148816	F9 V	5831	4.22	−0.73	111
149009	K5 III	3853	1.60	0.30	211
149161	K4 III	3910	1.39	−0.17	111
149414	G5 V	4941	4.55	−1.36	121
149661	K0 V	5159	4.56	0.13	132
150177	F3 V	6019	3.99	−0.57	SKC
150275	K1 III	4642	2.55	−0.54	232
151203	M3 IIIab	3640	0.70		51
151217	K5 III	4137	1.52	−0.03	111
152792	G0 V	5612	4.12	−0.25	111
153210	K2 III	4557	2.28	0.05	111
153597	F6 Vvar	6211	4.36	−0.09	111
154783	Am	7782	4.05	0.30	411
155358	G0	5831	4.12	−0.67	111
156014	M5 Ib-II	3293	0.76		55
157089	F9 V	5785	4.12	−0.56	SKC
157214	G0 V	5682	4.25	−0.39	SKC
157881	K7 V	4065	4.50	0.38	231
157910	G5 III	5136	1.83	−0.26	111
159181	G2 Iab	5250	1.60	0.10	331
159307	F8	6193	3.89	−0.72	111
159332	F6 V	6187	3.84	−0.19	111
159561	A5 III	7986	3.96	0.01	441
160365	F6 III	6070	3.0		46
160693	G0 V	5768	4.14	−0.61	SKC
161797	G5 IV	5411	3.87	0.16	SKC
161817	A2 VI (HB)	7639	2.96	−0.95	441
162211	K2 III	4513	2.44	0.05	111
162555	K1 III	4650	2.49	−0.15	111
163506	F2 Ibe	6491	1.7	−0.35	161
163588	K2 III	4434	2.33	−0.02	111
163993	G8 III	5028	2.69	0.03	111
164058	K5 III	3904	1.31	−0.05	111
164136	F2 II	6693	2.70	−0.30	444
164259	F3 V	6737	4.00	−0.02	411
164349	K0.5 IIb	4445	1.50	0.39	111
164353	B5 Ib	13493	2.4		46
165195	K3p	4471	1.11	−2.15	SKC
165401	G0 V	5707	4.25	−0.45	111
165760	G8 III-IV	4932	2.55	−0.04	111
165908	F7 V	5928	4.24	−0.53	SKC
166161	G5	4905	2.31	−1.25	SKC
166207	K0 III	4764	2.20	0.04	232
166229	K2.5 III	4529	2.32	0.08	111
166620	K2 V	4944	4.47	−0.23	SKC
167006	M3 III	3470	0.70	0.00	512
167042	K1 III	4927	3.46	−0.19	111
167768	G3 III	5211	1.61	−0.65	232
168322	G8.5 IIIb	4805	2.17	−0.51	232
168656	G8 III	5056	2.82	−0.14	111
168720	M1 III	3810	1.10	0.00	515
168775	K2 III	4535	2.08	0.03	111
169191	K3 III	4299	2.23	−0.11	111
169414	K2.5 IIIab	4415	2.47	−0.12	111
170153	F7 V	6008	4.36	−0.33	113
170693	K1.5 III	4394	2.32	−0.38	111
171443	K3 III	4191	1.83	−0.08	111
172167	A0 V	9522	3.98	−0.64	444

of which is the objective of this series of papers, correlates linearly with metallicities in the CG97 scale, but shows a non-linear behaviour with respect to the ZW84 values (in agreement with the previous work from CG97, which suggested that the ZW84 may be non-linear with respect to the true [Fe/H] scale, although note there is no a priori reason to expect a linear behaviour); (ii) the main difference between the two scales occurs at the high [Fe/H] end, where the ZW84 scale overestimates the metallicities compared to the high-dispersion studies. The discrepancy is specially important for M71, the highest [Fe/H] globular cluster of our sample. We have checked that, if we assume the ZW84 [Fe/H] value for this cluster and if we fit the strength of the near-IR Ca triplet versus the

Table 5 – *continued*

HD/Other	SpT	T_{eff}	log *g*	[Fe/H]	Ref
172365	F8 Ib-II	5500	2.10	−0.64	333
172380	M4-5 II	3421	0.55		56
172816	M5.2 III	3369	0.50		56
172958	B8 V	11300	3.75		41
173399	G5 IV	5054	2.60	−0.39	232
173780	K3 III	4400	2.34	−0.06	111
174704	F1 Vp	7412	3.5	0.60	441
174912	F8	5746	4.32	−0.48	SKC
174947	G8-K0 II	4840	1.20	0.39	111
174974	K1 II	4750	1.10	−0.15	331
175305	G5 III	4899	2.30	−1.43	SKC
175317	F5-6 IV	6594	4.12	0.22	211
175535	G7 IIIa	5064	2.55	−0.09	111
175545	K2 III	4451	2.94	0.23	232
175588	M4 II	3483	0.6		56
175638	A5 V	8150	3.90		41
175743	K1 III	4635	2.45	−0.12	112
175751	K2 III	4680	2.49	−0.03	111
175865	M5 III	3420	0.50	0.14	515
176301	B7 III-IV	13100	3.50		41
176411	K2 III	4718	2.51	0.06	111
178717	K3.5 III	4308	1.0	−0.30	331
180711	G9 III	4800	2.67	−0.12	SKC
180928	K4 III	4000	1.30	−0.38	512
181615	B2 Vpe + · · ·	6545	3.9	0.48	464
181984	K3 III	4447	2.20	0.21	111
182293	K3 IVp	4505	3.00	0.19	232
182572	G8 IVvar	5570	4.19	0.31	SKC
182762	K0 III	4820	2.78	−0.14	111
182835	F2 Ib	7350	2.15	0.09	444
184406	K3 III	4520	2.41	0.01	SKC
184492	G8 IIIa	4529	2.11	−0.04	111
184499	G0 V	5738	4.02	−0.66	SKC
185144	K0 V	5260	4.55	−0.24	SKC
185018	K0 V	5550	1.3		66
185644	K1 III	4536	2.67	0.08	232
185859	B0.5 Iae	22780	2.80		41
186408	G2 V	5815	4.30	0.09	SKC
186427	G5 V	5762	4.43	0.07	SKC
186486	G8 III	4994	2.88	−0.06	111
186568	B8 III	10609	3.4		46
186791	K3 II	4187	1.40	−0.23	111
187299	G5 Ia	5010	1.10	0.15	161
187691	F8 V	6107	4.30	0.11	SKC
187923	G0 V	5662	4.21	−0.09	112
188056	K3 III	4244	2.01	0.17	111
188310	G9 IIIb	4635	2.51	−0.24	111
188510	G5 Vwe	5490	4.69	−1.59	SKC
188512	G8 IVvar	5041	3.04	−0.04	SKC
188727	G5 Ib var	5684	1.60	0.00	113
190360	G6 IV + M6 V	5594	3.89	0.25	111
190406	G1 V	5821	4.10	−0.03	232
190603	B1.5 Iae	19250	2.41		41
190608	K2 III	4795	2.63	0.01	111
191046	K0 III	4345	2.01	−0.63	232
192310	K0 Vvar	5045	4.50	0.08	131
192422	B0.5 Ib	22600	2.8		46
192947	G6-8 III	5000	2.82	−0.08	111
193370	F6 Ib	6200	1.59	0.02	333
193901	F7 V	5713	4.39	−1.11	111
194598	F7 V-VI	5887	4.27	−1.22	SKC
194839	B0.5 Ia	23500	2.8		46
195592	O9.5 Ia	29000	2.8		46
195593	F5 Iab	6600	1.95	0.09	412
195633	G0 Vw	6000	3.78	−0.77	SKC
195636	B8	5478	3.4	−2.65	441
196758	K1 III	4660	2.47	−0.06	111
196892	F6 V	5762	3.68	−1.12	111
197076	G5 V	5761	4.23	0.01	121
198149	K0 IV	5013	3.19	−0.19	SKC
198183	B5 V	14315	4.0		46
198478	B3 Iae	16325	2.19	−0.23	414
199191	K0 III	4759	2.53	−0.45	232
199478	B8 Iae	10800	1.9		44
199580	K0 III-IV	5039	3.50	−0.13	112
199960	G1 V	5773	4.19	0.18	111
200580	F9 V	5733	4.28	−0.67	111
200779	K6 V	4252	4.63		11
200790	F8 V	5928	4.13	−0.12	SKC
201099	G0	5829	4.11	−0.51	111
201381	G8 III	5007	2.65	−0.09	111
201626	G9p	4941	2.00	−1.50	331
201891	F8 V-VI	5854	4.45	−1.11	SKC
203344	K0 III-IV	4658	2.33	−0.17	111
204587	M0 V	4034	4.67		11
204771	K0 III	4917	2.60	−0.05	111
205153	G0 IV	5961	3.20	−0.01	222
205435	G8 III	4989	2.76	−0.26	111
205512	K1 III	4634	2.57	0.03	SKC
205650	F6 V	5665	3.48	−1.26	111
206078	G8 III	4667	2.87	−0.46	232
206165	B2 Ib	17760	2.66	−0.33	444
207076	M7 III	3008	0.00		51
207134	K3 III	4403	2.74	0.13	232
207260	A2 Ia	9100	2.09		41
207673	A2 Ib	9071	1.40	0.16	444
207978	F6 IV-Vwv	6244	4.00	−0.62	111
208501	B8 Ib	12200	2.2		46
208906	F8 V-VI	5965	4.20	−0.74	SKC
208947	B2 V	20559	3.9		46
209481	09 V	36300	3.9		46
209975	08 Ib	29647	3.30	0.30	444
210027	F5 V	6413	4.16	0.00	111
210295	G8	4746	1.50	−1.42	131
210745	K1.5 Ib	4500	0.75	0.22	333
210855	F8 V	6199	3.78	0.12	111
210939	K1 III	4443	2.30	0.04	111
211391	G8 III	4943	2.70	0.08	111
212496	G8.5 IIIb	4696	2.72	−0.34	111
212943	K0 III	4586	2.81	−0.34	SKC
213470	A3 Ia	8800	1.38		41
214376	K2 III	4580	2.48	0.20	111
215257	F8	5871	4.30	−0.71	111
215373	K0 III	4905	2.65	0.03	111
215648	F7 V	6169	4.02	−0.30	111
216131	G8 III	5018	2.78	−0.09	SKC
216143	G5	4496	1.27	−2.15	SKC
216174	K1 III	4390	2.23	−0.53	SKC
216228	K0 III	4768	2.49	0.01	SKC
216385	F7 IV	6179	3.98	−0.35	SKC
217476	G4 Ia	5100	0.00	0.00	111
217877	F8 V	5866	4.02	−0.19	111
218029	K3 III	4290	2.05	0.13	111
218031	K0 IIIb	4647	2.52	−0.14	111
218329	M1 IIIab	3810	1.10		51
218470	F5 V	6529	4.11	−0.10	211

atmospheric parameters (see Paper III), we obtain significant negative residuals in the sense that M71 should have a lower [Fe/H] (and therefore closer to the CG97 value) if it were to follow the behaviour of the rest of the sample stars (almost 700, most of them from the field). Furthermore, in general, the globular cluster residuals against the fitting functions derived in Paper III are significantly reduced when changing from the ZW84 to the CG97 scale. We think that this adds further support to the reliability of the CG97 metallicity scale.

Concerning the open clusters stars, we have not introduced important revisions to the adopted values in the Lick/IDS system. Basically, we have chosen metallicities derived spectroscopically

Table 5 – *continued*

HD/Other	SpT	T_{eff}	$\log g$	[Fe/H]	Ref	HD/Other	SpT	T_{eff}	$\log g$	[Fe/H]	Ref
218502	F3w	6030	3.76	−1.84	SKC	BD+ 09 3223	III	5274	2.00	−2.23	222
218658	G2 III	5160	2.62	0.02	111	BD+ 17 4708	F8 VI	6005	4.01	−1.74	SKC
218857	G6w	5082	2.41	−1.93	SKC	BD+ 18 5215	F5	6290	4.49	−0.40	331
219134	K3 Vvar	4717	4.50	0.05	SKC	BD+ 19 5116 A	M4 V	3200	4.91		51
219449	K0 III	4578	2.39	−0.09	SKC	BD+ 19 5116 B	M6 V	2950	5.06		51
219615	G9 III	4830	2.57	−0.42	SKC	BD+ 26 3578	B5	6165	4.06	−2.25	SKC
219617	F8w	5878	4.04	−1.39	SKC	BD+ 30 2034	K3 III	4500	0.40	−1.40	321
219623	F7 V	6155	4.17	−0.04	SKC	BD+ 30 2611	G8 III	4311	0.94	−1.36	SKC
219734	M2 III	3730	0.90	0.27	515	BD+ 34 2476	A4	6231	3.80	−2.10	111
219945	K0 III	4762	2.61	−0.16	111	BD+ 41 3306	K0 V	4913	4.5	−0.79	131
219962	K1 III	4605	2.14	−0.11	232	BD+ 43 0044 B	M6 V	3721	5.08	−1.40	511
219978	K4.5 Ib	4250	0.80	−0.15	331	BD+ 44 2051 A	M2 V	3544	4.85	−1.40	511
220009	K2 III	4416	2.24	−0.56	111	BD+ 52 1601	G5 IIIw	4893	2.00	−1.30	331
220321	K0 III	4502	2.39	−0.35	111	BD+ 56 1458	K7 V	4069	4.70	−0.18	115
221148	K3 IIIvar	4643	3.05	0.40	112	BD+ 58 1218	F8	4957	1.10	−2.59	121
221830	F9 V	5688	4.16	−0.44	SKC	BD+ 59 2723	F2	6111	4.25	−2.03	131
222107	G8 III	4600	2.88	−0.54	111	BD+ 61 154	Be				
222368	F7 V	6136	4.12	−0.14	111	BD+ 61 2575	F8 Ib	6241	1.85	0.35	111
224930	G3 V	5305	4.49	−0.75	SKC	BD− 01 2582	F0	5067	2.12	−2.32	121
231195	F5 Ia	7500	1.4		46	G 275−4	G	6010	4.05	−3.45	111
232078	K4-5 III-II	3996	0.30	−1.73	521	G 64−12	F0	6312	4.21	−3.35	111
232979	K8 V	3769	4.70	−0.33	515	Gl 699	M5 V	3201	5.00	−0.90	515
BD+ 01 2916	K0	4442	1.10	−1.50	321	Gl 725A	M4 V	3451	4.8		56
BD+ 02 3375	A5	5978	4.04	−2.35	SKC	Gl 725B	M5 V	3304	4.9		56
BD+ 04 2621	G0	4607	1.10	−2.55	321	Luyton 789−6	M7e	2747	5.09		51
BD+ 09 3063		4628	1.55	−0.75	311	Ross 248	M6e	2799	5.12		51

Table 6. Brief explanation for the different methods to derive the atmospheric parameters.

SKC	From Soubiran et al. (1998)
RF1	From calibrated and corrected sources on to SKC
RF2	From calibrated and corrected sources on to SKC & RF1
RF3	From non-calibrated sources. $4000 < T_{\mathrm{eff}} < 6300\,\mathrm{K}$
RF4	From non-calibrated sources. $T_{\mathrm{eff}} > 6300\,\mathrm{K}$
RF5	From non-calibrated sources. $T_{\mathrm{eff}} < 4000\,\mathrm{K}$
RF6	From spectral type and luminosity class (Lang 1991)

Table 7. Estimated uncertainties for the new categories. Columns are: categories, number of stars with at least two original references, total number of original references used and mean rms standard deviation error for each one of the three atmospheric parameters.

Category	N_{star}	N_{ref}	$\sigma_{T_{\mathrm{eff}}}$ $\sigma_{\log g}$ $\sigma_{[\mathrm{Fe/H}]}$
RF1 and RF2	179	492	60.9
	153	413	0.18
	171	519	0.09
RF3	7	16	117.6
	13	33	0.21
	3	7	0.10
RF4	27	93	721.4
	13	49	0.32
	8	39	0.29
RF5	11	34	112.8
	1	4	0.21
	0	0	–

by Friel and collaborators (see Friel 1995). In all the cases, these are consistent with more recent determinations. The main revision is for the cluster NGC 7789, whose Lick/IDS [Fe/H] was taken from Twarog & Tyson (1985). The new metallicity of this cluster, listed by Friel (1995), is fully consistent with the recent value derived from near-IR photometry by Vallenari, Carraro & Richichi (2000).

6.2 Effective temperatures

Due to the lack of direct measurements of effective temperatures for cluster stars (mainly for globular cluster stars), we calculated improved effective temperatures by means of colour–temperature calibrations. Several recent papers have presented detailed colour–temperature calibrations which take into account metallicity and gravity effects. From a theoretical point of view, the work of Houdashelt, Bell & Sweigart (2000, hereafter HBS) provides a grid of colours which has been obtained from synthetic spectra and put on to the observational system by comparing with field stars. It is appropriate for stars having $4000 \le T_{\mathrm{eff}} \le 6500\,\mathrm{K}$, $0.0 \le \log g \le 4.5$ and $-3.0 \le [\mathrm{Fe/H}] \le 0.0$. On the other hand, the work of Alonso, Arribas & Martínez-Roger (1996b) presents empirical colour calibrations for dwarfs and subdwarfs with $4000 \le T_{\mathrm{eff}} \le 8000\,\mathrm{K}$ and $-2.5 \le [\mathrm{Fe/H}] \le 0.0$. An analogous work for giants having $3500 \le T_{\mathrm{eff}} \le 8000\,\mathrm{K}$ and $-3.0 \le [\mathrm{Fe/H}] \le 0.5$ is presented by Alonso, Arribas & Martínez-Roger (1999). In the following, we will denote the calibrations from Alonso et al. (1996b) and Alonso et al. (1999) as ALO.

It is important to keep in mind that our purpose is not only to derive improved temperatures for the cluster stars but also to obtain a homogeneous set of temperatures with the field stars. In order to check whether the temperatures derived from the mentioned colour–temperature relations are on our reference system, we selected a subsample of 103 field stars from SKC which had both $B-V$ and $V-K$ data in the literature and compared their effective temperature with the values predicted by the colour–temperature calibrations. Input atmospheric parameters for the temperature predictions ($\log g$ and [Fe/H]) are those published in

Table 8. Final atmospheric parameters of cluster stars. References for effective temperatures: (1) derived from $B-V$ versus $T_{\rm eff}$ relations in ALO (Alonso et al. 1996b, 1999); (2) mean from $B-V$ and $V-K$ versus $T_{\rm eff}$ relations in ALO; (3) from Worthey et al. (1994). Surface gravities from Gorgas et al. (1999), Worthey et al. (1994) and references therein. See Table 9 for metallicity sources. Sources for spectral types of Coma and Hyades stars are as in Table 5. For the rest of the clusters, we list positions in the HR diagram (SGB: subgiant branch; GB: giant branch; HB: horizontal branch; AGB: asymptotic giant branch).

Name	SpT	$T_{\rm eff}$	log g	[Fe/H]	Ref
Coma A 3	G9 V	4974	4.530	−0.05	1
Coma A 13	K0 V	5284	4.540	−0.05	1
Coma A 14	G4 V	5224	4.320	−0.05	1
Coma A 21	G7 V	5110	4.410	−0.05	1
Coma T 65	G0 V	5918	4.300	−0.05	1
Coma T 68	A6 IV-V	7905	4.090	−0.05	1
Coma T 82	A9 V	7352	4.130	−0.05	1
Coma T 85	G1 V	5918	4.380	−0.05	1
Coma T 86	F6 V	6402	4.270	−0.05	1
Coma T 90	F5 V	6359	4.280	−0.05	1
Coma T 97	F9 V	6032	4.340	−0.05	1
Coma T 102	G1 V	5844	4.360	−0.05	1
Coma T 114	F8 V	6446	4.300	−0.05	1
Coma T 132	G5 V	5567	4.470	−0.05	1
Coma T 150	G9 V	5254	4.300	−0.05	1
Hya vB 10	G0 V	5954	4.410	0.13	1
Hya vB 15	G3 V	5640	4.340	0.13	2
Hya vB 17	G5 V	5544	4.530	0.13	2
Hya vB 19	F8 V	6271	4.270	0.13	1
Hya vB 21	K0 V	5227	4.570	0.13	1
Hya vB 26	G9 V	5439	4.500	0.13	1
Hya vB 31	G0 V	6030	4.310	0.13	1
Hya vB 35	F5 V	6576	4.250	0.13	1
Hya vB 36	F6 V	6576	4.240	0.13	1
Hya vB 37	F5 V	6708	4.180	0.13	2
Hya vB 63	G1 V	5772	4.220	0.13	1
Hya vB 64	G2 V	5689	4.390	0.13	2
Hya vB 73	G2 V	5886	4.350	0.13	2
Hya vB 81	F6 V	6441	4.300	0.13	1
Hya vB 87	G8 V	5439	4.480	0.13	1
Hya vB 95	A8 V n	7578	3.790	0.13	2
Hya vB 103	F0 V	7228	4.050	0.13	1
Hya vB 104	A6 V n	8380	3.870	0.13	3
Hya vB 111	F0 V	7573	4.030	0.13	1
Hya vB 112	Am	7888	4.150	0.13	1
Hya vB 126	F3 IV	7339	4.250	0.13	1
Hya vB 140	G5 V	5377	4.480	0.13	1
M10 II-76	AGB	4623	1.470	−1.41	1
M10 III-85	GB	4397	1.200	−1.41	1
M13 A 171	AGB	4566	1.070	−1.39	1
M13 B 786	GB	3891	0.620	−1.39	1
M13 B 818	AGB	5301	1.890	−1.39	1
M3 398	GB	4541	1.440	−1.34	1
M3 III-28	GB	4093	0.730	−1.34	2
M3 IV-25	GB	4367	1.210	−1.34	2
M5 I-45	HB	5758	2.610	−1.11	1
M5 II-51	GB	4627	1.690	−1.11	2
M5 II-53	HB	10460	3.660	−1.11	3
M5 II-76	HB	5974	2.700	−1.11	1
M5 III-03	GB	4031	0.660	−1.11	2
M5 IV-19	GB	4113	0.840	−1.11	2
M5 IV-59	GB	4245	0.850	−1.11	2
M5 IV-86	HB	5576	2.460	−1.11	2
M5 IV-87	HB	5864	2.630	−1.11	1
M67 F 084	HB	4733	2.320	−0.09	2
M67 F 094	SGB	6219	4.070	−0.09	2
M67 F 105	GB	4461	2.230	−0.09	2
M67 F 108	GB	4255	1.830	−0.09	2
M67 F 115	SGB	6004	3.890	−0.09	2
M67 F 117	SGB	5353	3.790	−0.09	2
M67 F 119	SGB	6095	3.940	−0.09	1
M67 F 125	SGB	6134	4.340	−0.09	1
M67 F 164	HB	4699	2.220	−0.09	2
M67 F 170	GB	4289	1.830	−0.09	2
M67 F 175	SGB	6055	4.340	−0.09	1
M67 F 193	GB	4928	3.300	−0.09	2
M67 F 224	GB?	4704	2.530	−0.09	2
M67 F 231	GB	4850	2.950	−0.09	2
M67 I-17	GB	4952	3.370	−0.09	2
M67 II-22	SGB	5042	3.650	−0.09	2
M67 IV-20	GB	4722	2.750	−0.09	2
M67 IV-68	SGB	5158	3.730	−0.09	2
M67 IV-77	SGB	4946	3.570	−0.09	2
M67 IV-81	SGB	5352	3.760	−0.09	2
M71 1-09	AGB	4672	1.670	−0.70	1
M71 1-21	GB	4364	1.460	−0.70	2
M71 1-34	HB	5075	2.470	−0.70	1
M71 1-37	GB	4574	2.180	−0.70	1
M71 1-39	HB	4976	2.430	−0.70	1
M71 1-41	HB	5123	2.480	−0.70	1
M71 1-53	GB	4167	1.420	−0.70	1
M71 1-59	GB	4623	2.440	−0.70	1
M71 1-63	AGB	4689	1.820	−0.70	1
M71 1-64	GB	4275	1.510	−0.70	1
M71 1-65	GB	4606	2.200	−0.70	1
M71 1-66	AGB	4465	1.470	−0.70	1
M71 1-71	GB	4404	1.810	−0.70	1
M71 1-73	GB	4793	2.520	−0.70	1
M71 1-75		4790	2.560	−0.70	2
M71 1-87		5075	2.470	−0.70	1
M71 1-95	AGB	4639	1.670	−0.70	1
M71 1-107	AGB	4919	1.930	−0.70	1
M71 1-109	GB	4723	2.570	−0.70	1
M71 A2	HB	4840	2.370	−0.70	2
M71 A4	AGB	4040	0.740	−0.70	2
M71 A9	GB	4151	1.390	−0.70	2
M71 C	HB	4892	2.390	−0.70	2
M71 S	GB	4247	1.390	−0.70	2
M71 X	HB	5170	2.490	−0.70	2
M71 KC 147		4901	2.640	−0.70	1
M71 KC 169		5014	2.440	−0.70	1
M71 KC 263		4883	2.660	−0.70	1
M92 I-10	HB	9290	3.440	−2.16	3
M92 I-13	HB	5641	2.220	−2.16	1
M92 II-23	HB	7510	3.050	−2.16	3
M92 III-13	GB	4178	0.580	−2.16	2
M92 IV-114	GB	4728	1.580	−2.16	2
M92 VI-74	HB	5752	2.210	−2.16	1
M92 IX-12	AGB	5677	1.930	−2.16	1
M92 XII-8	GB	4477	1.000	−2.16	2
M92 XII-24	HB	11100	3.750	−2.16	3
NGC 188 I-55	SGB	5375	3.910	−0.05	1
NGC 188 I-57	GB	4740	3.070	−0.05	1
NGC 188 I-61	GB	4915	3.350	−0.05	1
NGC 188 I-69	GB	4427	2.350	−0.05	1
NGC 188 I-75	GB	4895	3.220	−0.05	1
NGC 188 I-85	GB	4820	3.550	−0.05	1
NGC 188 I-88	SGB	5195	3.850	−0.05	1

SKC. $B-V$ input values were the mean values taken from the electronic data base in Mermilliod, Mermilliod & Hauck (1997), while $V-K$ data were extracted, in order of preference, from Johnson et al. (1966), Johnson, MacArthur & Mitchell (1968), Carney (1983) and Laird (1985). The comparison is shown in Fig. 3 and reveals a systematic deviation of the temperatures predicted by HBS for low-metallicity stars, whereas no significant deviations owing to metallicity effects are found in the data from ALO. Thus, in order to preserve the homogeneity and quality of the final data, we decided to use only ALO to derive the effective

Table 8 – *continued*

Name	SpT	T_{eff}	log g	[Fe/H]	Ref	Name	SpT	T_{eff}	log g	[Fe/H]	Ref
NGC 188 I-97	SGB	5110	3.820	−0.05	1	NGC 188 II-181	GB	4300	2.190	−0.05	1
NGC 188 I-105	HB	4613	2.190	−0.05	1	NGC 188 II-187	GB	4936	3.330	−0.05	1
NGC 188 I-116		5148	3.230	−0.05	1	NGC 6171 04	HB	6039	2.750	−0.95	1
NGC 188 II-52	SGB	5501	3.940	−0.05	1	NGC 6171 45	HB	5856	2.840	−0.95	1
NGC 188 II-64	SGB	5808	4.090	−0.05	1	NGC 7789 415	GB	3885	1.060	−0.24	1
NGC 188 II-67	SGB	5956	4.130	−0.05	1	NGC 7789 468	GB	4228	1.600	−0.24	1
NGC 188 II-69	SGB	6032	4.170	−0.05	1	NGC 7789 501	GB	4102	1.380	−0.24	1
NGC 188 II-72	GB	4410	2.410	−0.05	1	NGC 7789 575	GB	4506	1.980	−0.24	1
NGC 188 II-76	HB	4578	2.180	−0.05	1	NGC 7789 669	GB	4214	1.570	−0.24	1
NGC 188 II-79	SGB	5055	3.550	−0.05	1	NGC 7789 676	HB	4961	2.320	−0.24	1
NGC 188 II-88	GB	4543	2.710	−0.05	1	NGC 7789 859	GB	4625	2.270	−0.24	1
NGC 188 II-93	SGB	5469	3.930	−0.05	1	NGC 7789 875	HB	4921	2.360	−0.24	1
NGC 188 II-122	GB	4936	3.410	−0.05	1	NGC 7789 897	HB	4921	2.350	−0.24	1
NGC 188 II-126	GB	4936	3.450	−0.05	1	NGC 7789 971	GB	3860	1.030	−0.24	1

Table 9. Adopted metallicities ([Fe/H]) for the cluster stars. Sources: (1) Carretta & Gratton (1997); (2) Rutledge, Hesser & Stetson (1997), in the CG97 scale; (3) Boesgaard & Friel (1990); (4) Friel & Boesgaard (1992); (5) Friel & Janes (1993); (6) Friel (1995).

Cluster	Lick/IDS	This paper	Source
M3	− 1.70	− 1.34	1
M5	− 1.30	− 1.11	1
M10	− 1.50	− 1.41	1
M13	− 1.50	− 1.39	1
M71	− 0.56	− 0.70	1
M92	− 2.20	− 2.16	1
NGC 6171	− 0.99	− 0.95	2
Hyades	+ 0.13	+ 0.13	3
Coma	− 0.07	− 0.05	4
M67	− 0.10	− 0.09	5
NGC 188	− 0.00	− 0.05	6
NGC 7789	− 0.10	− 0.24	6

temperatures of our library cluster stars. It is worth noting that, in our stellar population synthesis model, these empirical colour–temperature relations are preferred over the theoretical ones (see Paper IV).

Following the procedure described in Section 3, we have calibrated the effective temperatures predicted by ALO on to the system of SKC (see Fig. 4). For temperatures derived from the $B-V$ relations, a statistically significant offset of 26 K was found, which has been applied to correct and bootstrap the predicted data against the reference system. In contrast, no significant deviation has been found for temperatures derived from the $V-K$ relations. In addition, the fact that the rms standard deviations from the fits are very similar ($\sigma_{B-V} = 75$ K and $\sigma_{V-K} = 78$ K) allows us to deduce that the data quality of both predictions is the same. Thus, final effective temperatures for cluster stars were calculated by averaging the temperatures derived from $B-V$ and $V-K$ relations (when only $B-V$ was available, final temperatures were exclusively derived from this colour). Input metallicities are those previously established in Section 6.1, while gravities are the same as in G93 and W94. Concerning the input colours, $V-K$ values where taken from G93, whilst $B-V$ colours are from Mermilliod et al. (1997) for Coma and Hyades, W94 for a few horizontal-branch stars, and G93 for the rest of the sample. The reddening corrections were applied using the colour excesses given by G93.

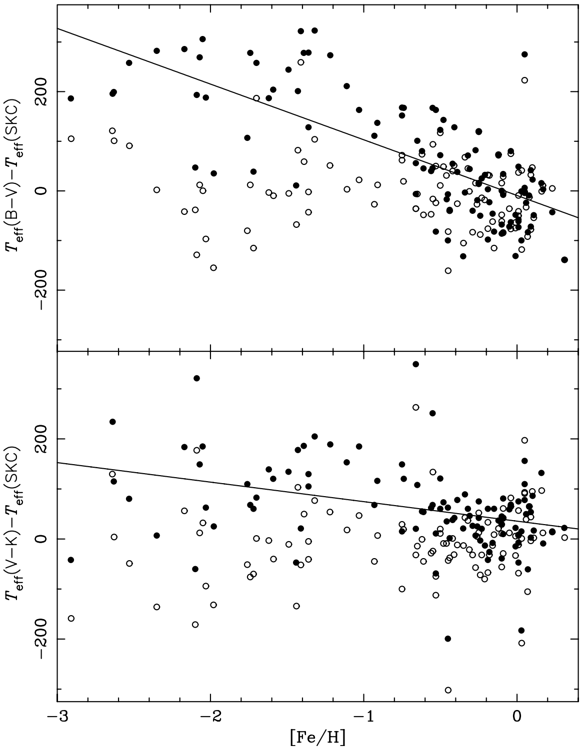

Figure 3. Temperature differences between colour–temperature calibrations [$T_{\mathrm{eff}}(B-V)$ and $T_{\mathrm{eff}}(V-K)$] and the reference system [T_{eff}(SKC)]. Filled and open circles are, respectively, data derived from the colour–T_{eff} calibrations of HBS and ALO for a subsample of 103 library stars. The solid line displays a least-squares fit to the filled circles.

It is important to note that, because of the validity range of the colour–temperature calibrations, the effective temperatures of the hot stars Hya vB 104, M5 II-53, M92 I-10, M92 II-23 and M92 XII-24 could not be predicted in this way. In these cases, temperatures from W94 were kept.

6.3 Surface gravities

Surface gravities for most of the cluster stars were originally derived by G93 by fitting the location of the stars in the HR diagrams to different evolutionary tracks (see the original paper for details on the tracks that were used). In the recent years, and thanks to the new Hipparcos data, distances and absolute ages of most globular clusters have been substantially modified (see e.g. Carretta et al. 2000 and references therein). In this work we have studied what changes should be introduced in the derived surface gravities to account for the new, usually larger, distances and, therefore, younger ages for the globular cluster stars. Changes in the effective temperatures do not affect the derived gravities since the original values were computed by matching only absolute magnitudes to avoid uncertainties in the colour–$T_{\rm eff}$ determinations. Using the relation $\Delta(\log g) = \Delta[\log(M/{\rm M}_\odot)] + 0.4\Delta M_{\rm bol}$ and applying the analytic formulae by Hurley, Pols & Tout (2000) to convert an age difference to a mass change for the stars in the different evolutionary phases, we have checked that distance and age effects tend to cancel each other, leading to systematic differences in $\log g$ always below 0.05 dex (for all the globular clusters with the exception of M71). This offset is below the uncertainties associated with the employed evolutionary tracks and the assumed metallicities and, therefore, we have decided not to change the gravities derived in G93.

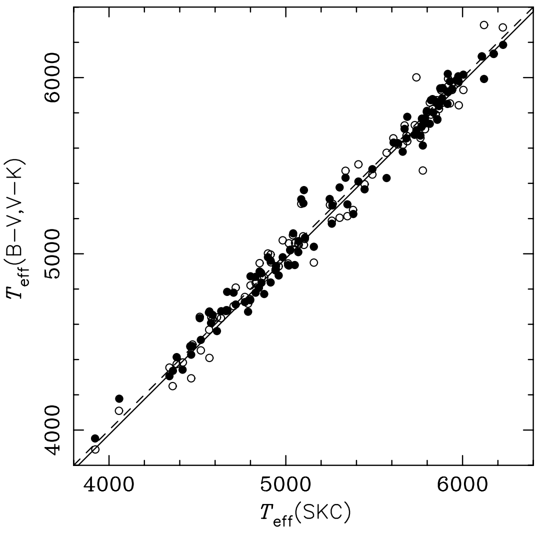

Figure 4. Comparisons between effective temperatures derived from ALO calibrations and those presented in SKC. Filled and open circles, respectively, are stars with $T_{\rm eff}$ derived from $B - V$ and $V - K$ calibrations. The dashed line is the one-to-one relation. The solid line $T_{\rm eff} = T_{\rm eff}$ (SKC) – 26 marks a significant offset of 26 K for effective temperatures derived from $B - V$. No significant deviation is observed for effective temperatures predicted from $V - K$.

The case for M71 is more uncertain since the Hipparcos based distance modulus [$(m - M)_V = 14.06$, Reid 1998] is rather larger than that employed in G93 [$(m - M)_V = 13.40$]. Furthermore, Salaris & Weiss (1998) have lowered the colour–magnitude derived age from 18 Gyr assumed in G93 to only 9.2 Gyr. We must note here that if we assume the distance modulus from Reid (1998), we are unable to fit the location of the stars in the M71 horizontal branch to theoretical isochrones, while a modulus around $(m - M)_V = 13.60$ (employed in the colour–magnitude diagram analyses of Hodder et al. 1992, Geffert & Maintz 2000 and Rosenberg et al. 2000) can explain the position of these stars. Assuming the latter distance, we have checked that the original gravities should be decreased or increased by ~ 0.05 dex for ages of 9.2 and 15 Gyr, respectively. We have therefore assumed that the gravities given by G93 are correct within the uncertainties associated with the absolute parameters of this cluster.

To summarize, we have not introduced any change in the gravities given by G93. Systematic errors of the order of 0.10 dex (well below the random errors given in Table 7 for the field stars) may still exist for the absolute gravities of the cluster stars. The detailed investigation of these errors is beyond the scope of this work, and, in any case, they do not represent a major drawback for the purposes of this series of papers.

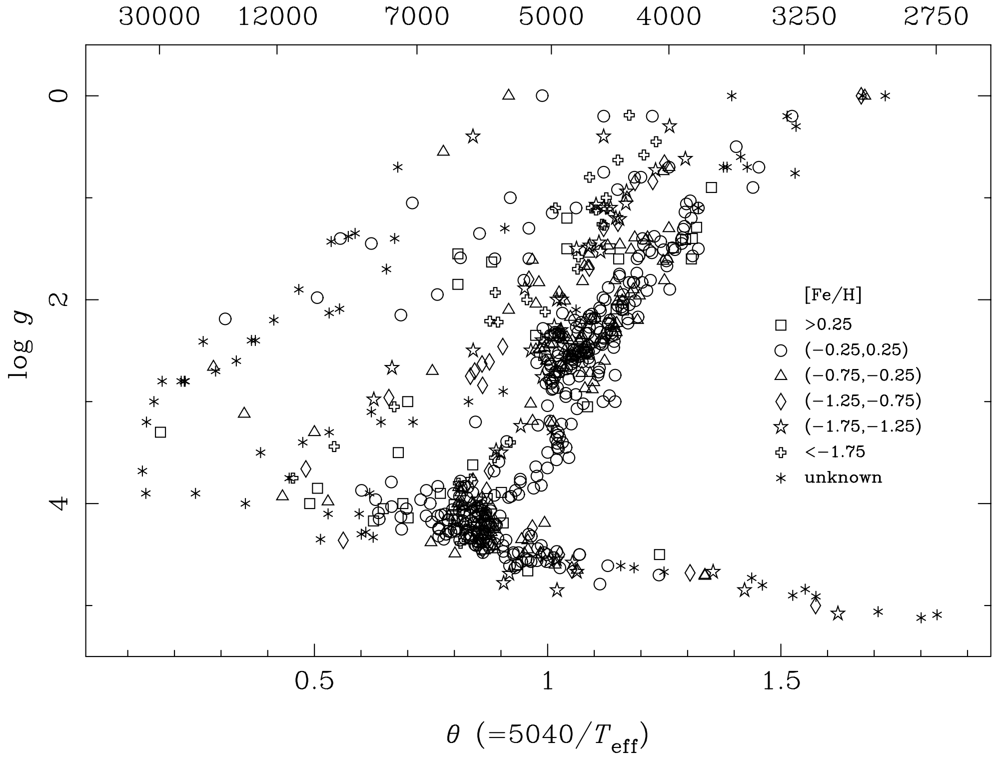

Figure 5. Gravity–temperature diagram for the library stars. Different symbols are used to indicate stars of different metallicities, as shown in the key. The upper scale gives effective temperatures in K.

7 SUMMARY

The uncertainties in the input atmospheric parameters are one of the main sources of potential errors when computing the predicted line-strengths of composite stellar systems using evolutionary synthesis models. In this paper we have derived a reliable, and highly homogeneous, set of atmospheric parameters ($2747 < T_{\rm eff} < 38367$, $0.00 < \log g < 5.12$ and $-3.45 < [{\rm Fe/H}] < +0.60$) for the 706 stars which constitute a new stellar library in the near-IR spectral range of the calcium triplet (λ8350–9020). Systematic deviations between parameters from different sources have been calibrated and corrected by bootstrapping them on to a reference system. Fig. 5 shows the complete stellar library in the parameter space of temperature and gravity for various metallicity ranges. In the forthcoming papers, the results of this work will be used to derive empirical fitting functions for the calcium triplet index (Cenarro et al., Paper III, in preparation) and to predict the integrated spectral energy distributions of stellar populations in the near-IR spectral range (Vazdekis et al., Paper IV, in preparation). Moreover, the utility of the new set of improved parameters goes beyond the objectives of this series. In particular, it should represent a basic ingredient for the new generation of spectral synthesis work and to improve the existing empirical calibrations of other relevant spectral features.

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