LOW-RESOLUTION SPECTROSCOPY OF RR LYRAE STARS IN THE HIC

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ABSTRACT

Low-resolution spectra of 30 RR Lyrae stars contained in the Hipparcos Input Catalogue have been obtained. The targets were selected from among those for which no measurements were available, or only poor ones, of metallicity and radial velocities in the updated catalogues (Suntzeff et al. 1994; Layden 1994). Metallicities have been obtained according to two different methods; Preston's classic ΔS method and the Freeman & Rodgers (1975) method as adapted by Layden (1994). Based on recent high-resolution spectra and ΔS data compiled from the literature, we have estimated the [Fe/H] versus ΔS relationship. While a slope of -0.20 seems to be the best value fitting our data, in good agreement with recent results, the zero-point of our calibration (0.11) is slightly higher than previous ones. This value brings the Layden metal abundance scale into agreement with those metallicities derived by Suntzeff et al., following the classic ΔS method. Otherwise the globular cluster and RR Lyrae metallicities turn out to be within the same scale when this zero-point value is used.

Key words: RR Lyrae stars; metal abundance; ΔS method.

1. INTRODUCTION

RR Lyrae stars present one of best groups of objects for the study of the structure and evolution of the Galaxy (e.g Layden 1994), at the same time as defining a primary distance pattern that is valid for globular clusters and Local Group galaxies (Saha et al. 1992, Mateo 1996). These reasons, among others, have led a hundred or so of these variables to be included as targets of the Hipparcos mission, with a view to recalibrating the M_V versus [Fe/H] ratio. This project evidently requires reliable measurements of the metallicities of these objects.

Most metallicity estimates for RR Lyrae stars are based on equivalent width measurements of the CaII K line (Preston 1959), and high-resolution spectroscopy (HRS) has only been used to determine the metallic abundance of almost one hundred of these variables (see Solano et al. 1997 and referenes therein). Although the M_V versus [Fe/H] ratio has been reviewed with high-resolution spectra with high signal-noise ratio, there remains a need to obtain reliable ΔS values for the RR Lyrae sample in the Hipparcos Input Catalogue (HIC) which will enable us (a) to recalibrate the $[Fe/H]_B$ versus ΔS relationship, and (b) estimate the metallicity of these objects on a homogeneous abundance scale.

In this paper we set about determining the metallicity of 30 RRab variables in the HIC, using two different methods based on the CaII K line, namely: (a) the classic ΔS method (Preston 1959), (b) the method devised by Freeman & Rodgers (1975) and later developed by Layden (1993). As a necessary step in the process of obtaining these metallicities we performed the [Fe/H] versus ΔS calibration in the light of the latest [Fe/H] measurements obtained by HRS.

2. THE DATA

The spectra were taken during three observation campaigns between 1993 and 1995 at the Roque de los Muchachos and Calar Alto observatories. The spectral range was chosen in order to include the CaII K (3924 Å) and $H\beta$ (4861 Å) lines (see Figure 1).

The typical resolution of the instrument configurations used was 4 Å. Exposure times were in all cases less than 30 minutes, in order to minimize 'phase blurring', thus providing a signal-to noise ratio of $\geq$ 50 for each spectrum. Besides the programmed stars, standard spectral-type stars (between $A0$ and $F9$) were also observed in each campaign, together with a set of patterns compiled by Layden (1994) for the calibration of Layden's Equivalent Width System. Spectra were processed using IRAF package. ΔS values were estimated following the procedures described by Suntzeff et al. (1994, 1996). The final [Fe/H] Butler scale estimates were obtained according to the [Fe/H] versus ΔS calibration discussed in the following section. A new set of [Fe/H] values in the Zinn & West abundance scale, for the same stars, was obtained following the methodology developed by Layden (1994). Table 1 shows the ΔS, $[Fe/H]_B$ and $[Fe/H]_{ZW}$ estimates for our target stars.

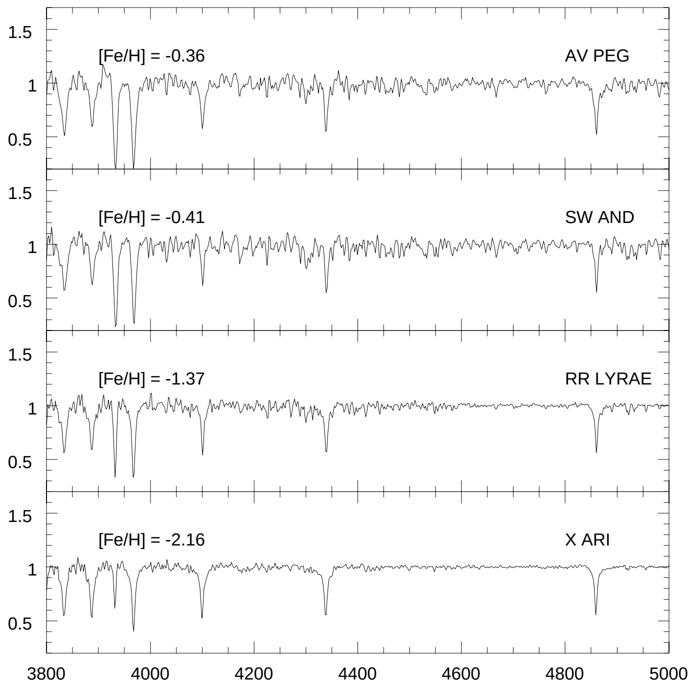

Figure 1. Spectra of several target stars used in this study.

3. $[Fe/H]_B$ VERSUS ΔS CALIBRATION

Clementini et al. (1995), Lambert et al. (1996) and Fernley & Barnes (1996) reanalyzed the ΔS, [Fe/H] calibration based on a detailed analysis of RRab star abundances. These authors used high signal-to-noise and high dispersion spectra to derive their metallicities. Each of these calibrations referred to its own abundance scale, which depends on—among other factors—the inclusion of non-LTE effects and the selection of various model parameters, such as microturbulence, gravity and temperature. Since most of the major RR Lyrae metallicity surveys (Blanco 1992; Suntzeff et al. 1994) refer to Butler's abundance scale (1975), we have adopted the criterion of remeasuring the calibration for the Butler scale. In other words, we are not trying to find the 'real' abundance scale but rather attempting to redefine the ΔS, $[Fe/H]_B$ ratio in the light of the metallicities obtained by HRS.

HRS [Fe/H] estimates together with the ΔS values taken by Blanco (1992) and Suntzeff et al. (1994) are shown in Table 2. The metallicities of Clementini et al. (1995), Lambert et al. (1996) and Fernley & Barnes (1996) were then shifted to the Butler scale. A weight average was subsequently obtained for both [Fe/H] and ΔS variables. The resulting values for 22 RRab stars are plotted in Figure 2 (black squares). A linear fit yields:

$$[Fe/H]_B = -0.200(\pm 0.008)\Delta S + 0.13(\pm 0.05)$$

High resolution spectroscopic [Fe/H] estimates for 14 RRab variables in globular clusters (see Jurcsik 1995 for references on individual measurements) versus the

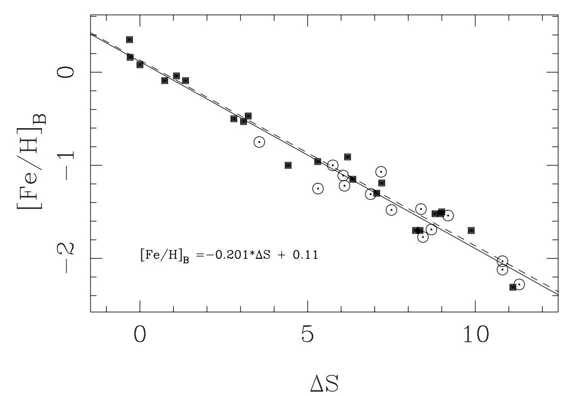

Figure 2. HRS Metallicity in the Butler scale versus ΔS. Black squares denote field RRab Lyrae while open circles denote variables in globular clusters. The metallicities of the globular variables are in different abundance scales.

ΔS values taken from Costar & Smith (1988) are also shown in Figure 2 (open circles). Note that the [Fe/H] values for the cluster variables are an amalgamation of different results obtained by several authors and have not been tied to a common abundance scale. Despite the larger dispersion of the cluster data, they present a good fit with the linear relation derived from the field RRab variables alone. A new calibration has been obtained by putting together both set of data, yielding:

$$[Fe/H]_B = -0.201(\pm 0.007)\Delta S + 0.11(\pm 0.05)$$

Since both calibrations are identical within the error range, we may consider the second one to be representative of the actual $[\mathrm{Fe/H}]_B$ versus ΔS calibration. The slope of the adopted calibration is very similar to that reported by Lambert et al. (1996) and Fernley & Barnes (1996), although our zero-point is larger than those of these authors by 0.24 and 0.27, respectively.

4. DISCUSSION

The calibration given in the previous section resolves a minor inconsistency in the [Fe/H] values published by Layden (1994) and ΔS values reported by Suntzeff et al. (1994). Layden (1993) found that the relationship between the Zinn & West (1984) and Butler (1975) abundance scales was:

$$[\mathrm{Fe/H}]_{ZW} = 0.90(\pm0.05)[\mathrm{Fe/H}]_B - 0.34(\pm0.06)$$

which can be expressed in terms of ΔS by substituting the Butler (1975) calibration. This produces:

$$[\mathrm{Fe/H}]_{ZW} = -0.144\Delta S - 0.54$$

However, a comparison between the $[\mathrm{Fe/H}]_{ZW}$ (Layden 1994) and ΔS (Suntzeff et al. 1994) values for common stars leads to the equation:

$$[\mathrm{Fe/H}]_{ZW} = -0.189(\pm0.008)\Delta S - 0.23(\pm0.05)$$

which significantly differs from the previous one.

This empirical relationship can be reproduced if our calibration in ΔS is used instead Butler's original equation:

$$[\mathrm{Fe/H}]_{ZW} = -0.181(\pm0.011)\Delta S - 0.24(\pm0.08)$$

On the other hand, if we assume that the peak in the distribution of ΔS amongst field RR Lyrae is between 7.5 and 8 (Fernley 1993), the $[\mathrm{Fe/H}]_{ZW}$ obtained from our calibration is -1.69, in good accordance with the peak in $[\mathrm{Fe/H}]_{ZW}$ for the halo globular clusters of -1.69 (Laird et al. 1988).

Table 1. Estimated metallicity for the target variables. Subscript B denotes the metallicity obtained from classic ΔS method, while subscript L indicates the metallicity estimated following the Layden procedure. Those stars marked with asterisk are located below $|b| \leq 10°$ and present severe contamination by interstellar CaII.

Object	ΔS	$[\mathrm{Fe/H}]_B$	$[\mathrm{Fe/H}]_L$
AT AND	4.8	-0.85	-1.46
SW AND	0.2	0.07	-0.50
CH AQL	10.1	-1.91	-0.82(*)
BH AUR	8.1	-1.51	-0.71 (*)
X ARI	12.1	-2.31	-2.29
ST BOO	10.0	-1.89	-1.95
V363 CAS	6.0	-1.09	-0.14(*)
RR CET	7.4	-1.37	-1.69
UU CET	6.6	-1.21	-1.44
AA CMI	-	-	-0.50
XZ CYG	7.6	-1.41	-1.65
UY CYG	4.8	-0.85	-1.50 (*)
V1719 CYG	7.6	-1.41	-0.13 (*)
SU DRA	7.4	-1.37	-1.63
XZ DRA	2.6	-0.41	-1.0
RX ERI	-	-	-1.17
SV ERI	9.0	-1.69	-1.83
SZ GEM	10.9	-2.07	-1.66(*)
VX HER	5.2	-0.93	-1.56
CZ LAC	1.0	-0.09	-0.87(*)
RR LYR	6.4	-1.17	-
EZ LYR	5.0	-0.89	-1.40
V440 SGR	5.3	-0.95	-1.26(*)
AV PEG	-0.7	0.25	-0.07
AR PER	0.6	-0.01	-0.67
KN PER	0.9	-0.07	-0.28(*)
HK PUP	10.1	-1.91	- 1.37(*)
XX PUP	7.5	-1.39	-1.57 (*)
RV UMA	5.8	-1.05	-1.79
BN VUL	7.2	-1.33	-1.64(*)

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