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A method for determining [Fe/H] for c-type RR Lyrae based upon Fourier Coefficients

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Abstract. The metal abundance for c-type RR Lyrae stars using a [Fe/H] - ϕ_{31} - $\log P$ relation is investigated. The relation obtained is similar to that found by Jurcsik & Kovács (1996) for field ab-type RR Lyrae stars, where lower metallicity stars tend to have larger periods for similar values of the Fourier coefficient ϕ_{31}. Our relation is used to determine the metallicity of field c-type RR Lyrae stars, those within ω Cen, and variables in the LMC. The results based upon our relation compare favorably to metallicity values obtained elsewhere.

Key words. stars: abundances – stars: variables: other – globular clusters: general

1. Introduction

Fourier functions have been frequently used to determine the pulsation period, P, of regular variables. The light variation over time is fit to the relation

$$V(t) = A_0 + \sum_{i=1}^{n} A_i \cos(i\omega t + \phi_i) \qquad (1)$$

where the A_i and ϕ_i are the Fourier coefficients of the fit of degree n, and $\omega = 2\pi/P$. Simon & Lee (1981) combined these terms in the following manner - $R_{ij} = A_i/A_j$ and $\phi_{ij} = \phi_i - i\phi_j$, and showed that additional information about pulsating variables could be obtained from these combinations of Fourier coefficients.

Jurcsik & Kovács (1996, hereafter JK) used field ab-type RR Lyrae (RRab) to derive a relationship between P, ϕ_{31} and [Fe/H] which has been widely used to determine RRab metallicity. A similar relation for c-type RR Lyrae variables (RRc) had previously not been obtained, possibly due to the lack of data for field RRc variables. Such a relation is readily apparent in various studies of RRc stars. Simon (1990) showed that the distribution of ϕ_{31} with period would vary according to Oosterhoff group, with Oosterhoff I cluster stars having larger values of ϕ_{31} for a given value of P than stars from Oosterhoff II clusters. This trend was also observed in several clusters (Clement et al. 1992, 1993), and has been used to estimate the metallicity of RRc variables in the direction of the galactic bulge (Morgan et al. 1998) and 47 Tuc (Morgan & Dickerson 2000).

We have collected the Fourier coefficients from 128 RRc variables taken from 17 globular cluster with [Fe/H] values between −0.53 and −2.26. The cluster metallicities are combined with the Fourier coefficients to obtain a [Fe/H] - ϕ_{31} - $\log P$ relation analogous to that of JK. Full details of the method have been submitted

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for publication elsewhere (Morgan et al. 2006). We present here some of the initial results from this study.

2. Results

We were able to obtain several relations between $\log P$, ϕ_{31} and [Fe/H] that are able to fit the globular cluster RRc data adequately. The relation which we found to be the most reliable is

$$[\mathrm{Fe/H}] = 3.70(\log P)^2 + 0.124\phi_{31}^2 - 0.845\phi_{31} - 1.02 \log P\phi_{31} - 2.62. \quad (2)$$

Morgan et al. (2006) derived several relations that can also be used to estimate RRc metallicity, however, in the analysis that follows we use only Equation 2. The first test case made use of field RRc stars. There are only 34 field RRc stars with [Fe/H] values and good quality V magnitude light curves that can be used to determine metallicity using Equation 2. These [Fe/H] values can be compared to those from the literature, which are mainly based upon ΔS, though some stars had only one value of ΔS while others had widely divergent values. The comparison of the [Fe/H] values based primarily upon ΔS and Equation 2 show a large variation in value. The outliers tend to be stars with either single or divergent values of ΔS. A few of the stars also had abnormally large ϕ_{31} values which produced suspect [Fe/H] values when Equation 2 is used. The RRc variables in ω Cen were also examined. Equation 2 was applied to a total of 54 variables from the cluster. The [Fe/H] values obtained showed a rather wide distribution of values. This is not surprising given the broad range of metallicity observed in ω Cen (Hilker et al. 2004). We obtained values for [Fe/H] ranging from -1.83 to -1.32, with a mean of -1.59 ± 0.14. The largest concentration of values is near -1.64, which is within the range of the dominant metallicity population of ω Cen.

The Fourier coefficients of 682 RRc variables in the Large Magellanic cloud are given in Alcock et al. (2004). Equation 2 was applied to all of these stars and an average metallicity of [Fe/H] $= -1.51 \pm 0.41$ was found. There were significant deviations from this value, with some positive metallicity values also obtained. The average [Fe/H] value is very similar to that of Gratton et al. (2004), who found a value of -1.48 for 101 RR Lyrae, and very similar to other values for the metallicity of LMC RR Lyrae (Borissova et al. 2001; Marconi & Clementini 2005).

Even though these results are encouraging, we do realize that the metallicity relation provided here will no doubt evolve as more high quality light curves for RRc stars are made available. In particular, values of ϕ_{31} for RRc stars in clusters with very high or very low metallicities would be useful to refine and improve the formula we derived.

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References

Alcock, C., et al. 2004, AJ, 127, 334
Borissova, J., Catelan, M., & Valchev, T. 2001, MNRAS, 324, 77
Clement, C. M., Jankulak, M., & Simon, N. R. 1992, ApJ, 395, 192
Clement, C. M., Ferance, S., & Simon, N. R. 1993, ApJ, 412, 183
Gratton, R. G., Bragaglia, A., Clementini, G., Carretta, E., Di Fabrizio, L., Maio, M., & Taribello, E. 2004, A&A, 421, 937
Hilker, M., Kayser, A., Richtler, T., & Willemsen, P. 2004, A&A, 422, 9
Jurcsik, J., & Kovács, G. 1996, A&A, 312, 111
Marconi, M., & Clementini, G. 2005, AJ, 129, 2257
Morgan, S. M., & Dickerson, C. 2000, Acta Astron., 50, 249
Morgan, S. M., Simet, M., & Bargenquast, S. 1998, Acta Astron., 48, 341
Morgan, S. M., Wahl, J. N., & Wieckhorst, R. M. 2006, submitted to MNRAS
Simon, N. R. 1990, ApJ, 360, 119
Simon, N. R., & Lee, A. S. 1981, ApJ, 248, 291