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Estimating Cepheid Metallicities: a new approach

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Abstract. A relation between the Fourier decomposition parameters of Cepheid light curves and metallicities in the form [Fe/H]=$f(\{R_{i1}, \varphi_{i1}\})$ is presented. It gives [Fe/H] values with prediction errors 0.16–0.22 dex depending on the number of Fourier parameters used in the relation.

1. Introduction

A new method has been introduced to estimate RR Lyrae metallicities from the light curves by Kovács & Zsoldos (1995). It is based on the assumption that the light curve shape depends only on a finite (and small) number of parameters, e.g., mass, luminosity, chemical compositions, etc. Here I apply this method to Cepheids, another application is given by Jurcsik & Kovács (1995). A full description of the method is given by Kovács & Zsoldos (1995).

2. The data

I used 58 stars with well covered UBV light curves and with photometric metallicities given by Harris (1981). The light curves were fitted with an 8th- or higher order Fourier-sum.

The overall accuracy of the fits is about $0\overset{\mathrm{m}}{.}02$–$0\overset{\mathrm{m}}{.}04$, the relative error of the Fourier components is low ($< 10\%$), reaching 50% only in some cases for $A_7 - A_8$.

3. The relation

Four cases were studied, quadratic fits with 2–5 parameters. The most important parameters (i.e., appearing in all four cases) are φ_{31} (a metallicity indicator in RR Lyrae stars, too!) and R_{51}. The prediction error decreased from 0.22 to 0.16 as the number of parameters increased from 2 to 5. The equation for the five parameter quadratic case is:

$$\begin{aligned}
[\mathrm{Fe/H}] &= 0.334 + 0.109p_4 + 3.360p_5 + 34.211p_1^2 - \\
&- 7.386p_1p_2 - 111.617p_1p_3 + 2.146p_1p_4 + \\
&- 0.675p_2^2 - 0.535p_2p_4 + 15.875p_2p_5 + \\
&+ 1.717p_3p_4 + 208.527p_3p_5 - 8.961p_4p_5 - \\
&- 255.853p_5^2
\end{aligned}$$

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where $p_1 = A_1 - 0.371$, $p_2 = \varphi_{21} - 2.887$, $p_3 = R_{31} - 0.151$, $p_4 = \varphi_{31} + 1.054$ and $p_5 = R_{51} - 0.070$ (the phases refer to a sine decomposition).

Some coefficients were omitted from the equation because their relative errors were larger than 60%. Their omission did not change the prediction accuracy, it still remains 0.16.

4. Conclusions

Cepheid light curves show a similar type of correlation with metallicity as the RR Lyrae stars do. Though three of the five parameters are identical, it is interesting to note the lack of period dependence in the case of Cepheids.

The main uncertainty of the result lies in the uncertainties of the metallicities. There are few spectroscopic [Fe/H] determinations and they usually do not pay attention to the phase. The correlation between the existing spectroscopic data and Harris' metallicities is not as good as one would wish.

Figure 1 compares the three- and five parameter fits of Cepheids and the five parameter fit of RR Lyrae stars.

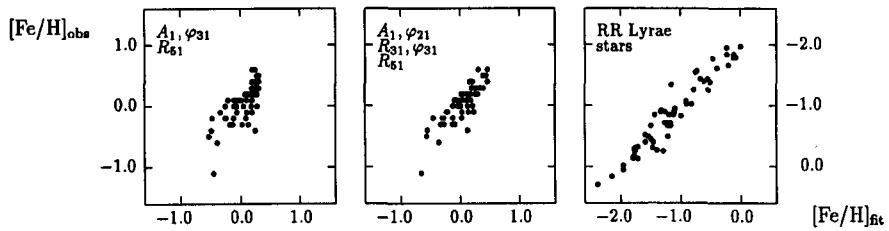

Figure 1. Three- and five parameter fits of Cepheids and the five parameter fit of RR Lyrae stars respectively.

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References

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