ON THE APPLICATION OF FOURIER DECOMPOSITION PARAMETERS

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1. Introduction

The application of Fourier decomposition parameters has revolutionized important areas of investigations of Cepheid type variables since the introduction of Fourier analysis in its modern form by Simon and Lee (1981).

In the literature several different representations of the results of Fourier analysis have been utilized. In view of the growing interest for applications of Fourier decomposition it is important to use and publish Fourier data in an optimal way. Most studies until now have used amplitude ratios and phase differences derived from traditional light curves giving the light variation in magnitudes, following the original recipe of Simon and Lee (1981). However, Stellingwerf and Donohoe (1986) advocated the use of phases rather than phase differences. Recently, Buchler et al. (1990) argued that the standard Simon & Lee form contains all relevant physics, and suggested analysis of flux-values rather than of magnitudes, because this removes the distorting effects of constant, false light. Thus there are many choices to be made in practical applications of Fourier analysis, and there is at present no convincing argument for preferring one specific representation.

2. Phase Definitions

For the precise definition of phases of the type proposed by Stellingwerf and Donohoe (1986; SD in the following) there are several possibilities. We here use the mean light curves of RRab variables in ω Centauri published by Martin (1938) to compare three natural choices.

Let us evaluate three different possibilities for the standard point defining the phases: (1) the point at which the rising branch crosses the mean magnitude, m_o, (2) the point at which the rising branch crosses the median magnitude, $m_{0.5} = 0.5(m_{\min} + m_{\max})$, and (3) light maximum. In order to make comparisons with the remarkable pattern in the phases of the simple pulsation models discussed by SD, we choose in cases (1) and (2) 0.5 for the phase of the standard point. For convenience we denote in the following the phases of cases (1) and (2) C_k and D_k, respectively. In order to compare with Payne-Gaposchkin's (1947) analysis we choose in case (3) as standard phase 0.0 (these phases are G_k in the following). Comparing C_k, D_k, and G_k

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we find the most interesting results for the phases D_k. In nearly all stars D_k with (1-2) σ follow the prediction of the simple models of alternating phases $D_k = \pi/2$ or $3\pi/2$. This is in beautiful agreement with the "sawtooth" case, which should also correspond to light curves of high skewness. The phases C_k show significant differences between their average values and the prediction from the simple models, and G_k plots resemble traditional phase difference plots (as in *e.g.* Petersen, 1984) with no indication of a simple explanation of their basic properties. We conclude, therefore, that both the phases C_k and G_k are less interesting than D_k, and that D_k should be preferred in future work.

In order to discuss bump progression sequences it is important to compare data for RRab variables with similar data for Cepheids. For periods 3–7 days classical Cepheids show a pattern very similar to that of the RRab stars in ω Cen: a linear decrease of D_1 with period and $D_2 \approx \pi/2$, $D_3 \approx 3\pi/2$, and $D_4 \approx \pi/2$. And the classical Cepheids of period 7–20 days show the Hertzsprung progression in D_k similar to the less well defined progression sequence in Type II variables of period 1–4 days (Petersen and Andreasen, 1987). We conclude that the D_k phases agree very well with the simple SD models outside resonances, and that they seem to provide improved possibilities for future comparisons of pulsation properties of RR Lyrae stars, Type II Cepheids, and classical Cepheids.

In view of the meager information on advantages and disadvantages of different representations of Fourier parameters, we recommend: (i) Published tables of observational results should give amplitudes and phases directly together with their standard errors and the SD standard phase; (ii) The original observational data should be easily available for calculation of new types of Fourier decomposition parameters.

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