PERIOD ANALYSIS OF THE RR LYRAE STAR AE BOOTIS

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ABSTRACT. The Fourier analysis performed for photoelectric Penston's (1972) observations of the RR_c Lyrae variable AE Boo shows that the star may be multiperiodic with most significant frequencies f_{1H}, f_F, f_{2H}, $3/2f_F$, $5/4f_F$ and their linear combinations.

Key words: Stars: RR Lyrae type, Fourier analysis

By using Breger's (1991) program PERIOD the Fourier analysis was carried out of photoelectric V-magnitudes for the c-type RR Lyrae star AE Boo obtained by Penston (1972) within 3 years (J.D. 2439971 - 2441065) which gave the following elements consistent with observations:

$$Max_{hel} = J.D.2440771.810 + 0.314897\,E \quad (1)$$

With the light variation amplitude of 0.44 mag the mean light curve shows a scatter of 0.1 mag. The following idea suggests itself: the star may be multiperiodic.

The Fourier analysis has given the most significant value of the fundamental period P_{1H}=0.3148956^d (f_{1H}=3.1756547). After subtracting it the Fourier analysis of residuals has displayed several dominating frequencies. The reduction of residuals with each of the corresponding periods to the mean curve failed to yield the result expected: the mean curves showed nearly the same scatter as the curve with respect to the fundamental period. Therefore, fits with frequencies multiple with the fundamental (f_{1H} and its harmonics) were performed to observations in order to take into account the light curve asymmetry. This fit was subtracted from observations and for residuals the Fourier analysis was done. In the power spectrum significant frequencies can be seen. They had larger amplitudes or comparable with those of subtracted harmonics. Therefore, harmonics of frequency f_{1H} higher then the third were substituted by the most significant constituents with frequencies: $f_F=3/4f_{1H}$, $f_{2H}=5/3f_F$, $f_{3H}=2f_F=3/2f_{1H}$ and f_{4H}.

With the value of P_F=0.420^d for AE Boo Petersen's (1990) models with enhanced metal opacity provide a very good agreement of period ratios for first four overtones to P_F (for P_{4H} somewhat worse) with our determinations and multiplicity ratios: P_{1H}/P_F=0.748, P_{2H}/P_F=0.596, P_{3H}/P_F=0.500, P_{4H}/P_F=0.428.

Standard models constructed for Population I pulsators are less suitable in this case: P_{1H}/P_F=0.765, P_{2H}/P_F=0.610, P_{3H}/P_F=0.509, P_{4H}/P_F=0.435.

In Table 1 are represented results of the fit giving minimum residuals: frequencies, amplitudes, phases, f_F/f_i ratios and theoretical ones close to them from multiplicity viewpoint, as well as identifications. Besides the above frequencies there are also linear combinations of f_{1H} and f_F according to the formula:

$$f_{ij} = if_{1H} + jf_F, \quad (2)$$

used by Jerzykiewicz et al. (1982) when analyzing the light curve of AQ Leo.

However, there are two more frequencies introduced by us: $f_E = 5/4f_F$ and $f_G=3/2f_F$, and their combinations: $f_{4H}=f_F + f_E$, $2f_E=f_F + f_G$, $3f_E=f_{4H} + f_G$. In the case of AE Boo observations are also represented as a synthetic light curve being a sum of sinusoids:

$$m(t) = \bar{m} + \Sigma_i A_i \sin[2\pi f_i(t - t_0) + \varphi_i], \quad (3)$$

its main terms are given in Table 1.

In addition to harmonics of fundamental and first overtones in AQ Leo described by Jerzykiewicz et al. (1982) and discovered by Fitch

Table 1. Results of fits with minimum residuals.

$freq_i$	Amp_i	φ_i	f_F/f_i	$(f_F/f_i)_{theor}$	P_i	ident.
2.3795079	0.025	0.242	1	1	0.42025496	f_F
2.9787811	0.012	0.728	0.799	0.800	0.3357077	$f_E=5/4f_F$
3.1756544	0.214	0.561	0.749	0.750	0.31489572	$f_{1H}=4/3f_F$
3.5735541	0.015	0.494	0.666	0.667	0.2798334	$f_G=3/2f_F$
3.9698965	0.014	0.951	0.599	0.600	0.25189573	$f_{2H}=5/3f_F$
4.7603339	0.013	0.282	0.500	0.500	0.21006929	$f_{3H}=2f_F$
5.3698130	0.016	0.538	0.443	0.444	0.18622622	$f_{4H}=f_F+f_E$
5.9484201	0.017	0.560	0.400	0.400	0.1681118	$2f_E$
6.3524091	0.018	0.592	0.375	0.375	0.15742059	$2f_{1H}$
7.1400110	0.009	0.149	0.333	0.333	0.1400558	$2f_G$
4.4644466	0.015	0.621	0.533	0.533	0.2239919	$3/2f_E$
8.9304208	0.014	0.582	0.266	0.267	0.1119768	$3f_E=f_{4H}+f_G$
7.9403691	0.017	0.834	0.300	0.300	0.1259387	$2f_{2H}=f_{1H}+f_{3H}$
9.5303409	0.013	0.233	0.250	0.250	0.10492804	$3f_{1H}$

and Szeidl (1976) fundamental, first and second overtones in AC And, in the light curve of AE Boo there arise frequencies f_E and f_G too as well as their linear combinations.

To formula (3) are subjected also observations of the c-type RR Lyrae star ST CVn with its three basic frequencies found by Penicke et al. (1989), 0.755, 3.0395, 6.1950 c/d, which we identify with $f_{1H}/4$, f_{1H} and $2f_{1H}$, respectively. As in the case AE Boo, the frequency f_{1H} is dominating here which is characteristic of c-type RR Lyrae pulsators. At such an identification the ratios of periods: $P_{1H}/4P_{1H}=0.249$ and $(P_{1H}/2)/P_{1H}=0.491$ are close to theoretical ones from the multiplicity viewpoint. And there is no necessity of resorting to the hypothesis of a nonradial pulsator. Thus, formula (3) reflects the essence of multimodal light variations of stars.

Observational range of AE Boo being represented within 3 years with 15 nights only, a further large set of observations would be needed in order to confirm results obtained.

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