1982

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Simon, Norman R. and Teays, Terry J., "The Light Curves of RR Lyrae Field Stars" (1982). *Faculty Publications, Department of Physics and Astronomy*. 86.
https://digitalcommons.unl.edu/physicsfacpub/86

THE ASTROPHYSICAL JOURNAL, **261**:586–594, 1982 October 15

THE LIGHT CURVES OF RR LYRAE FIELD STARS

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Received 1982 February 8; accepted 1982 April 23

ABSTRACT

Fourier decompositions have been made of the light curves of a large sample of RR Lyrae field stars. The coefficients have been tabulated. Following the scheme of an earlier investigation of classical Cepheids, certain combinations of the low-order coefficients—ϕ_{21}, R_{21}, and ϕ_{31}—are plotted against period. The Bailey-type *c* pulsators stand out from the type *ab* stars, particularly on the R_{21} plot which is found to be a more sensitive discriminator of Bailey type than is the traditionally employed amplitude-period diagram. We compare the RR Lyrae plots of ϕ_{21}, R_{21}, and ϕ_{31} with those previously obtained for classical Cepheids. It is noted that, while the Cepheid plots display a tightly defined progression with period, reflecting the influence of a modal resonance, in the RR Lyrae case there is much more scatter. However, some evidence is shown to exist for a Cepheid-like progression appearing among the longer period RR Lyrae pulsators and culminating in the unique small-amplitude variable XZ Ceti. New observations will be required to confirm the reality of such a progression.

Subject headings: stars: pulsation — stars: RR Lyrae

I. INTRODUCTION

In a recent investigation, Simon and Lee (1981) performed Fourier decompositions of the light curves of a large selection of classical Cepheids. It was shown that certain combinations of the low-order Fourier coefficients changed with period in such a way as to provide a quantitative description of the Hertzsprung progression. In the present work we extend the technique to the RR Lyrae domain. The light curves of 70 RR Lyrae pulsators, all field stars, are subjected to Fourier analysis, and combinations of the coefficients again plotted against period. In analyzing the data we seek to answer two questions: (1) Do the RR Lyrae stars show any regular progression similar to that displayed by the classical Cepheids? and (2) Is the well-known qualitative dichotomy in curve shape between the Bailey type *c* stars and the Bailey type *ab* stars confirmed quantitatively by the Fourier decompositions?

II. FOURIER DECOMPOSITIONS

The Fourier fitting is described by Simon and Lee. Fits to the observed visual magnitudes have the form:

$$V = A_0 + A_i \cos\left[i\omega(t - t_0) + \phi_i\right], \qquad (1)$$

where, in the present investigation, the index i runs from 1 to 8 in all but one case. Thus, while many of the Cepheid light curves in Simon and Lee could be fitted by four terms, the RR Lyrae fits were noticeably improved by going to eighth order. Criteria for the sufficiency and appropriateness of the fits are the same as those given by Simon and Lee.

The fits described in equation (1) are always to observations expressed in the standard *UBV* system. Data published in other systems were converted before fitting. The time t in equation (1) is employed in the form

$$t = \mathrm{JD} - \tau,$$

where JD is the time of the observation in Julian days. The quantities τ and t_0 are constants but in general have different values for each star. The former quantity is given in Table 1, the latter in Table 2.

The list of stars chosen for study is displayed in Table 1. The bulk of the sample comes from the work of Lub (1977), who has kindly supplied us with his observations in tabular form. These and other observations are referenced in the source column of Table 1. Other columns in the table give the published Bailey type, the period, the amplitude, the number of observations presented to the fitting routine, and the standard deviation of the fit, multiplied by 100. As explained by Simon and Lee, the periods given here should not be considered definitive.

For a number of stars, the data sets were larger than could be accommodated by the fitting program. In these cases a selection of data was made, as indicated in the final column of Table 1. For yet other stars, a variable light curve is suspected, either because such a suspicion has already been voiced in the literature or because our examination of the data has indicated some question. This circumstance is also noted in the last column.

TABLE 1

LIST OF STARS IN THE SURVEY

Star No.	Star Name	Bailey Type	Source	Period	Amplitude	No. of Obs.	σ (x 100)	Notes
1	BB Hyi	c	L1	.287131	0.54	69	2.31	
2	CG Lib	c	L1	.3068674	0.63	103	2.74	
3	RZ Cep	c	P	.308645	0.56	200	0.67	1
4	HD16456	c	D1	.311331	0.53	100	0.99	
5	BY Eri	c	L1	.311349	0.53	75	2.34	
6	MT Tel	c	L3	.316899	0.62	152	1.40	
7	T Sex	c	L1	.3246980	0.46	106	1.54	
8	V487 Sco	c	L1	.3291385	0.51	88	1.95	
9	AA Aql	ab	L1	.3617869	1.33	126	3.38	
10	RW TrA	ab	L1	.3740351	0.77	84	1.95	
11	SV Scl	c	L1	.37760	0.52	97	1.59	
12	RU Psc	c	P	.39040	0.49	158	1.26	
13	HH Pup	ab	L1	.3907463	1.40	139	2.87	
14	V445 Oph	ab	L1	.3970228	0.90	129	1.85	
15	AM Tuc	c	L1	.405689	0.46	105	2.11	3
16	W Crt	ab	L1	.4120134	1.33	142	2.78	
17	V494 Sco	ab	L1	.4273326	1.00	175	2.00	
18	SW And	ab	M	.44227	0.95	127	2.05	
19	RV Cap	ab	D2	.4477502	1.15	83	2.96	2
20	ST Oph	ab	L1	.4503564	1.31	108	3.28	
21	S Ara	ab	L1	.451883	1.33	180	2.30	
22	RR Leo	ab	O	.45238172	1.38	244	3.40	
23	V455 Oph	ab	L1	.4539182	0.90	110	3.05	
24	VX Her	ab	L1	.45537280	1.35	149	2.51	
25	SW Aqr	ab	L1	.4593029	1.31	147	3.26	
26	CP Aqr	ab	L1	.463407	1.31	119	2.50	
27	DN Pav	ab	L2	.46844376	1.39	200	4.10	1
28	DX Del	ab	L4	.4726239	0.75	200	1.69	1
29	V440 Sgr	ab	L2	.47747883	1.29	200	2.44	1
30	SV Hya	ab	L1	.4785439	1.32	191	2.72	
31	BB Pup	ab	L1	.480544	1.06	143	2.88	
32	BR Aqr	ab	L1	.4818785	1.19	166	2.55	
33	FW Lup	ab	L3	.4841712	0.41	169	1.04	
34	ST Pic	ab	D1	.48574	0.48	99	1.51	
35	AV Ser	ab	L1	.4875571	1.14	134	2.23	
36	V690 Sco	ab	L1	.4922558	1.12	133	2.28	
37	SS For	ab	L1	.495432	1.36	124	2.60	
38	TY Aps	ab	L1	.5016935	1.09	136	3.85	2
39	RZ Cet	ab	L2	.5106077	0.98	164	3.49	
40	V499 Cen	ab	L1	.521210	1.22	200	2.38	1
41	AN Ser	ab	L1	.52207070	1.05	149	1.88	
42	AF Vel	ab	L1	.5273984	0.96	157	2.64	
43	RY Psc	ab	L1	.5297291	0.84	138	2.94	
44	VY Lib	ab	L1	.5339377	1.04	182	2.90	
45	RR Cet	ab	L1	.5530253	0.98	139	1.67	
46	V452 Oph	ab	L1	.55716230	1.02	115	2.94	
47	RV Oct	ab	L1	.571130	1.16	200	3.21	1
48	TZ Aqr	ab	L1	.5711943	0.86	119	2.62	
49	WY Ant	ab	L2	.57433095	0.93	68	1.93	
50	V341 Aql	ab	L2	.57802054	1.27	200	2.27	1
51	RX Eri	ab	D1	.5872462	0.90	200	2.08	1
52	V413 CrA	ab	L1	.5893240	0.70	165	1.72	
53	RV Phe	ab	L1	.5964182	0.69	135	2.26	
54	TT Lyn	ab	O	.59743406	0.74	200	2.10	1
55	UU Cet	ab	L1	.606081	0.70	172	2.47	
56	YY Tuc	ab	L1	.635021	1.19	131	2.28	
57	FY Hya	ab	L1	.636651	1.19	200	4.65	1
58	V675 Sgr	ab	L1	.6422895	0.97	200	1.88	1

TABLE 1—*Continued*

Star No.	Star Name	Bailey Type	Source	Period	Amplitude	No. of Obs.	σ (x 100)	Notes
59	UY Boo	ab	L1	.6508446	1.18	200	3.25	1,2
60	X Ari	ab	L1	.6511336	0.99	200	1.76	1
61	AV Vir	ab	L1	.656908	0.79	140	2.33	
62	SU Dra	ab	O	.6604189	1.03	96	1.71	
63	TV Leo	ab	L1	.6728430	1.29	184	2.93	
64	BO Aqr	ab	L1	.6940186	1.13	142	2.69	
65	TY Pav	ab	L1	.7104425	0.92	152	2.33	
66	VY Ser	ab	L1	.7140931	0.73	177	1.51	
67	X Crt	ab	L1	.7328332	0.71	166	1.79	
68	IU Car	ab	L1	.737108	1.01	162	1.85	
69	AT Ser	ab	L1	.74656820	0.92	163	1.75	
70	XZ Cet	?	D1	.8231	0.48	234	1.00	

NOTES.—(1) Selected data set. (2) Light curve may be variable. (3) Fourth-order fit.

SOURCES.—D1: Dean *et al.* 1977, $\tau = 2{,}440{,}000$; D2: Dean *et al.* 1977, $\tau = 2{,}442{,}600$; L1: Lub 1977, $\tau = 2{,}441{,}000$; L2: Lub 1977, $\tau = 2{,}440{,}000$; L3: Lub 1977, $\tau = 2{,}442{,}000$; L4: Lub 1977, $\tau = 2{,}439{,}000$; M: McNamara and Feltz 1977, $\tau = 2{,}443{,}000$; O: Oláh and Szeidl 1978, $\tau = 2{,}436{,}000$; P: Paczynski 1965, $\tau = 2{,}438{,}000$.

Tables 2 and 3 give the Fourier coefficients (A_i, ϕ_i) according to equation (1) for all of the stars in our sample. Following Simon and Lee, we shall attempt to quantify the structure of the light curves by employing combinations of the low-order coefficients, viz.,

$$R_{21} = A_2/A_1, \quad \phi_{21} = \phi_2 - 2\phi_1, \quad \phi_{31} = \phi_3 - 3\phi_1.$$

Figures 1, 2, and 3 display the plots versus period of ϕ_{21}, R_{21}, and ϕ_{31} respectively. We may compare these plots with Figures 1, 2, and 4 of Simon and Lee which show the same quantities versus period for classical Cepheids. It is immediately obvious that the RR Lyrae graphs display considerably more scatter, a circumstance which argues for a much greater inhomogeneity in the RR Lyrae sample as compared with that of the Cepheids. That this should be the case is not surprising since most observed Cepheids are thought to be on a particular crossing of the instability strip, whereas the RR Lyrae stars may not have a single, common, interior structure or evolutionary history.

The Bailey type *ab* stars are indicated by filled circles in Figures 1–3, while the type *c* stars are denoted by crosses. The two groups are segregated in all three figures but most decisively by far in Figure 2. For comparison, we plot in Figure 4 the standard amplitude-period diagram for the stars of our sample. Not only is there much more scatter in this diagram compared with Figure 2, but two of the circles are seen to lie among the crosses. These stars are FW Lupi and ST Pictoris. Although the former star was classified *ab* by Lub (1977), neither of the two light curves (which appear very similar to the eye) conform very well to the classical categories. However, on the basis of Figure 2, these stars may now indeed be classified as type *ab*. The R_{21}-period diagram thus seems to provide a clearer test of Bailey type than do the criteria previously employed.

Traditionally, the type *c* stars are accepted as a distinct group, generally taken to be characterized by first-overtone pulsation. The Fourier decompositions, discussed above, contain nothing which disputes this. However, our sample does include a unique star, which is not easily fitted into the general picture. This object is XZ Ceti, represented in Figures 1–4 by a circle containing a cross. XZ Ceti is a small-amplitude pulsator whose light curve is rather typical of Bailey type *c* and whose values of ϕ_{21}, R_{21}, and ϕ_{31} fall well within the type *c* ranges. On the other hand, this star has a period of 0.823 days, the longest of any star in our sample. In addition, a careful perusal of Figures 1–3 yields the following interesting observation. If one considers only the longer period stars, say $P \gtrsim 0.55$ days, then the progressions of ϕ_{21}, R_{21}, and ϕ_{31} with period resemble those detected for the classical Cepheids, as may be seen by comparing Figures 1, 2, and 4 from Simon and Lee. In particular, the sharp rise of ϕ_{21} and ϕ_{31}, and the sharp fall of R_{21}, around 0.8 days parallel the behavior of the classical Cepheids near 10 days.

To be sure, these parallels rest upon somewhat sketchy evidence. In the first place, as noted earlier, the RR Lyrae stars show considerable scatter. Secondly, and more important, the inference we have advanced depends strongly upon one star, namely, XZ Ceti itself. While it thus seems premature to assert the existence of a "Hertzsprung progression" for the RR Lyrae stars, the possibility of such a progression is intriguing. In the classical Cepheids, the abrupt changes of the Fourier coefficients at 10 days are believed to be due to a

TABLE 2

FOURIER COEFFICIENTS (A_i, ϕ_i) (where $i = 1$–4)

Star No.	Star Name	t_o	A_o	A_1	ϕ_1	A_2	ϕ_2	A_3	ϕ_3	A_4	ϕ_4
1	BB Hyi	993	12.06	2.50(-1)	6.28	4.14(-2)	4.61	2.03(-2)	2.88	2.11(-2)	1.46
2	CG Lib	143	11.50	2.68(-1)	5.50	5.66(-2)	3.10	1.79(-2)	2.78(-1)	1.97(-2)	4.38
3	RZ Cep	250	9.43	2.68(-1)	4.62	6.34(-2)	1.30	2.52(-2)	3.94	1.77(-2)	9.08(-1)
4	HD16456	2350	9.02	2.65(-1)	1.44(-1)	4.60(-2)	4.95	2.83(-2)	3.28	1.71(-2)	2.26
5	BY Eri	640	12.39	2.34(-1)	3.93	4.60(-2)	1.76(-1)	2.32(-2)	1.85	1.64(-3)	5.25
6	MT Tel	126.45	9.01	2.60(-1)	1.93	7.35(-2)	1.89	1.66(-2)	1.85	1.00(-2)	1.95
7	T Sex	372	10.06	2.15(-1)	3.88	2.23(-2)	3.12(-1)	1.31(-2)	3.00	8.32(-3)	4.92
8	V487 Sco	473	11.37	2.18(-1)	2.58	1.70(-2)	3.68	1.30(-2)	5.93	1.29(-2)	1.02
9	AA Aql	116	11.90	4.34(-1)	4.72	2.37(-1)	7.41(-1)	1.53(-1)	3.45	1.06(-1)	6.01
10	RW TrA	494	11.36	2.85(-1)	6.05	1.37(-1)	3.75	7.34(-2)	1.57	3.48(-2)	5.82
11	SV Scl	924	11.42	2.52(-1)	5.81	3.57(-2)	4.13	2.30(-2)	2.26	1.58(-2)	9.15(-3)
12	RU Psc	293	10.17	2.30(-1)	2.88	1.47(-2)	3.89	1.75(-2)	6.60(-1)	8.57(-3)	1.95
13	HH Pup	361	11.43	4.28(-1)	5.75	2.53(-1)	3.23	1.62(-1)	1.60(-1)	1.02(-1)	4.04
14	V445 Oph	195.8	11.05	3.12(-1)	6.20	1.56(-1)	4.04	8.76(-2)	2.05	4.32(-2)	1.15(-1)
15	AM Tuc	960	11.65	2.16(-1)	3.35	2.11(-2)	5.76	1.88(-2)	1.65	7.30(-3)	2.40
16	W Crt	448	11.63	4.38(-1)	9.27(-1)	2.45(-1)	5.80	1.44(-1)	4.75	1.06(-1)	3.56
17	V494 Sco	108	11.41	4.05(-1)	2.42	1.72(-1)	2.53	8.46(-2)	2.59	4.05(-2)	3.21
18	SW And	69	9.68	3.18(-1)	2.19	1.74(-1)	2.26	1.06(-1)	2.56	5.51(-2)	2.87
19	RV Cap	82	11.15	4.54(-1)	4.29	1.87(-1)	6.09	9.75(-2)	1.67	6.40(-2)	3.86
20	ST Oph	860	12.24	4.54(-1)	8.13(-1)	2.19(-1)	5.41	1.56(-1)	4.08	9.65(-2)	2.72
21	S Ara	148	10.84	4.32(-1)	3.82	2.12(-1)	5.16	1.64(-1)	5.51(-1)	1.05(-1)	2.25
22	RR Leo	200	10.83	4.55(-1)	6.91(-1)	2.28(-1)	5.16	1.61(-1)	3.69	9.91(-2)	2.33
23	V455 Oph	836	12.35	3.39(-1)	1.07	1.46(-1)	6.06	6.62(-2)	4.92	3.28(-2)	4.07
24	VX Her	439	10.78	4.58(-1)	4.51(-1)	2.12(-1)	2.61(-1)	1.64(-1)	2.56	1.06(-1)	4.96
25	SW Aqr	198	11.29	4.65(-1)	5.35	2.19(-1)	1.92	1.61(-1)	5.07	9.82(-2)	2.03
26	CP Aqr	527	11.86	4.32(-1)	5.13	2.44(-1)	1.67	1.40(-1)	4.81	9.84(-2)	1.83
27	DN Pav	135	12.54	4.57(-1)	2.18	1.99(-1)	1.88	1.54(-1)	1.73	1.06(-1)	1.88
28	DX Del	365	10.00	2.52(-1)	2.72	1.34(-1)	3.34	7.34(-2)	4.21	3.06(-2)	5.12
29	V440 Sgr	802	10.42	4.21(-1)	4.73	2.02(-1)	7.03(-1)	1.55(-1)	3.32	9.95(-2)	5.95
30	SV Hya	88	10.60	4.58(-1)	2.69	2.24(-1)	2.84	1.29(-1)	3.24	7.94(-2)	3.90
31	BB Pup	389	12.21	3.24(-1)	3.61	1.82(-1)	5.07	1.12(-1)	4.31(-1)	6.62(-1)	2.21
32	BR Aqr	153	11.50	3.77(-1)	3.07	2.00(-1)	3.84	1.38(-1)	4.93	8.33(-2)	6.13
33	FW Lup	185	9.05	1.61(-1)	3.51	6.19(-2)	4.96	2.36(-2)	5.75(-1)	6.58(-3)	2.48
34	ST Pic	2200	9.55	1.87(-1)	1.38	7.41(-2)	7.69(-1)	3.14(-2)	3.01(-1)	8.24(-3)	6.08(-1)
35	AV Ser	515	11.56	3.98(-1)	5.63(-3)	1.94(-1)	3.81	1.37(-1)	1.81	7.90(-2)	5.90

TABLE 2—*Continued*

Star No.	Star Name	t_o	A_o	A_1	ϕ_1	A_2	ϕ_2	A_3	ϕ_3	A_4	ϕ_4
36	V690 Sco	668	11.48	3.66(-1)	6.56(-1)	2.04(-1)	5.42	1.24(-1)	4.12	8.26(-2)	2.98
37	SS For	951	10.26	4.59(-1)	2.32(-1)	2.51(-1)	4.20	1.48(-1)	2.52	7.57(-2)	3.38(-1)
38	TY Aps	513	11.94	3.35(-1)	4.63	1.83(-1)	7.40(-1)	1.04(-1)	3.52	6.14(-2)	5.98
39	RZ Cet	1900	11.86	3.49(-1)	2.51	1.64(-1)	2.74	1.05(-1)	2.98	5.55(-2)	3.48
40	V499 Cen	125	11.17	4.23(-1)	6.21	1.92(-1)	3.71	1.46(-1)	1.44	1.00(-1)	5.55
41	AN Ser	464	11.00	3.66(-1)	1.32	1.85(-1)	6.34(-1)	1.04(-1)	2.21(-1)	6.58(-2)	5.83
42	AF Vel	410.5	11.48	3.77(-1)	7.61(-1)	1.38(-1)	5.36	9.37(-2)	3.94	6.16(-2)	2.61
43	RY Psc	300	12.42	2.89(-1)	1.30	1.47(-1)	1.16(-1)	8.46(-2)	5.81	4.26(-2)	4.97
44	VY Lib	164	11.75	3.33(-1)	8.69(-1)	1.71(-1)	5.66	1.20(-1)	4.59	7.46(-2)	3.50
45	RR Cet	943	9.76	3.20(-1)	2.16	1.61(-1)	1.98	1.13(-1)	2.15	6.95(-2)	2.41
46	V452 Oph	827	12.30	3.34(-1)	2.09	1.49(-1)	1.72	1.18(-1)	1.76	9.03(-2)	1.73
47	RV Oct	76	11.03	3.69(-1)	2.33	2.04(-1)	2.44	1.33(-1)	2.77	8.97(-2)	3.19
48	TZ Aqr	572	12.18	2.81(-1)	4.32	1.38(-1)	1.33(-1)	9.89(-2)	2.58	5.00(-2)	5.10
49	WY Ant	644	10.90	3.22(-1)	7.25(-1)	1.46(-1)	5.32	1.16(-1)	3.93	7.33(-2)	2.74
50	V341 Aql	625	10.94	4.23(-1)	5.36	2.25(-1)	5.04	1.34(-1)	3.54	9.96(-2)	2.17
51	RX Eri	1500	9.70	3.09(-1)	5.61	1.56(-1)	2.75	1.00(-1)	1.18(-1)	5.68(-2)	3.96
52	V413 CrA	491	10.63	2.49(-1)	3.11	1.15(-1)	4.07	7.70(-2)	5.23	3.64(-2)	2.48(-1)
53	RV Phe	906.5	11.98	2.45(-1)	1.66	1.24(-1)	1.02	6.51(-2)	7.95(-1)	3.96(-2)	5.72(-1)
54	TT Lyn	650	9.88	2.52(-1)	7.73(-1)	1.16(-1)	5.56	8.06(-2)	4.41	4.08(-2)	3.40
55	UU Cet	198	12.09	2.39(-1)	5.93	1.09(-1)	3.33	6.85(-2)	1.16	4.16(-2)	5.49
56	YY Tuc	920	12.07	4.04(-1)	3.37	2.21(-1)	4.40	1.37(-1)	5.72	9.02(-2)	9.37(-1)
57	FY Hya	104	12.63	3.93(-1)	2.85	1.61(-1)	3.31	1.31(-1)	3.95	8.33(-2)	4.49
58	V675 Sgr	166	10.39	3.25(-1)	6.37(-2)	1.53(-1)	4.03	1.18(-1)	2.05	7.59(-2)	1.11(-1)
59	UY Boo	416	11.03	3.78(-1)	3.35	1.78(-1)	4.23	1.37(-1)	5.38	9.02(-2)	3.02(-1)
60	X Ari	447	9.59	3.40(-1)	4.29	1.60(-1)	6.19	1.22(-1)	2.17	8.57(-2)	4.42
61	AV Vir	467	11.84	2.72(-1)	2.40	1.34(-1)	2.71	8.28(-2)	3.32	4.03(-2)	3.98
62	SU Dra	500	9.86	3.43(-1)	1.79	1.86(-1)	1.40	1.10(-1)	1.27	6.73(-2)	1.19
63	TV Leo	430	12.17	4.06(-1)	4.89	2.03(-1)	1.16	1.29(-1)	4.04	9.61(-2)	7.35(-1)
64	BO Aqr	608	12.23	3.63(-1)	2.36	1.89(-1)	2.56	1.21(-1)	2.96	6.97(-2)	3.58
65	TY Pav	537	12.62	3.07(-1)	5.98	1.56(-1)	3.59	9.15(-2)	1.32	5.09(-2)	5.52
66	VY Ser	442	10.15	2.62(-1)	3.50	1.26(-1)	4.91	7.83(-2)	2.38(-1)	3.53(-2)	2.08
67	X Crt	803	11.49	2.24(-1)	4.67	1.05(-1)	1.09	6.31(-2)	4.05	2.92(-2)	8.24(-1)
68	IU Car	756	11.99	3.63(-1)	4.10	1.66(-1)	6.01	1.01(-1)	1.66	6.84(-2)	3.90
69	AT Ser	804.5	11.53	3.23(-1)	1.94	1.59(-1)	1.87	1.02(-1)	1.80	5.76(-2)	1.91
70	XZ Cet	2000	9.47	2.20(-1)	5.42	3.76(-2)	3.24	2.33(-2)	8.24(-1)	6.08(-3)	4.84

TABLE 3

FOURIER COEFFICIENTS (A_i, ϕ_i) (where $i = 5$–8)

Star No.	Star Name	A_5	ϕ_5	A_6	ϕ_6	A_7	ϕ_7	A_8	ϕ_8
1	BB Hyi	9.82(-3)	3.68(-2)	1.12(-2)	3.32	1.22(-2)	1.42	4.25(-3)	4.03
2	CG Lib	1.36(-2)	2.18	1.39(-2)	5.26	8.17(-3)	2.78	8.92(-3)	5.57
3	RZ Cep	1.35(-2)	3.61	1.17(-2)	6.22	5.01(-3)	2.31	4.63(-3)	4.89
4	HD16456	1.22(-2)	4.62(-1)	9.97(-3)	4.94	6.66(-3)	3.41	3.36(-3)	7.91(-1)
5	BY Eri	4.94(-3)	7.46(-1)	9.50(-3)	3.73	3.89(-3)	2.49	9.53(-3)	8.11(-1)
6	MT Tel	5.60(-3)	1.35	4.89(-3)	1.48	4.53(-3)	1.62	1.51(-3)	1.11
7	T Sex	6.05(-3)	1.02	3.99(-3)	2.61	4.27(-3)	5.90	2.41(-3)	1.10(-1)
8	V487 Sco	6.31(-3)	1.12	2.80(-3)	3.68	5.13(-3)	6.71(-1)	3.56(-3)	3.52
9	AA Aql	6.59(-2)	2.36	4.53(-2)	4.93	3.93(-2)	1.28	3.07(-2)	3.84
10	RW TrA	1.69(-2)	3.64	6.20(-3)	7.43(-1)	5.65(-3)	4.83	1.03(-2)	4.83
11	SV Scl	6.18(-3)	4.23	4.68(-3)	2.05	9.78(-4)	4.36	3.70(-3)	2.44
12	RU Psc	5.85(-3)	2.76	6.53(-3)	4.76	3.78(-3)	5.58	2.76(-3)	4.05(-1)
13	HH Pup	7.35(-2)	1.13	4.49(-2)	5.08	3.73(-2)	1.98	3.16(-2)	5.88
14	V445 Oph	2.85(-2)	4.13	1.89(-2)	2.10	9.20(-3)	5.73	4.75(-3)	3.30
15	AM Tuc	—	—	—	—	—	—	—	—
16	W Crt	6.75(-2)	2.65	4.19(-2)	1.27	3.72(-2)	1.91(-1)	2.31(-2)	5.48
17	V494 Sco	1.34(-2)	3.40	1.11(-2)	4.10	5.00(-3)	1.52	2.62(-3)	3.89
18	SW And	3.54(-2)	2.93	1.99(-2)	3.24	1.38(-2)	3.88	4.05(-3)	3.32
19	RV Cap	2.34(-2)	1.62	8.77(-3)	2.33	9.61(-3)	3.67	9.46(-3)	1.50
20	ST Oph	7.14(-2)	1.37	5.11(-2)	1.90(-1)	3.12(-2)	5.11	2.28(-2)	3.57
21	S Ara	7.74(-2)	3.94	4.88(-2)	5.68	2.60(-2)	9.57(-1)	2.55(-2)	2.59
22	RR Leo	7.79(-2)	1.02	4.91(-2)	5.81	3.27(-2)	4.45	3.14(-2)	2.97
23	V455 Oph	9.67(-3)	2.78	4.62(-3)	2.85	4.28(-3)	2.34	1.15(-2)	1.85
24	VX Her	7.33(-2)	1.07	5.92(-2)	3.57	3.62(-2)	6.07	2.70(-2)	2.20
25	SW Aqr	7.62(-2)	5.24	5.39(-2)	2.28	3.88(-2)	5.55	2.48(-2)	2.31
26	CP Aqr	5.85(-2)	5.00	4.11(-2)	1.59	3.23(-2)	4.87	2.41(-2)	1.56
27	DN Pav	7.93(-2)	1.83	5.69(-2)	2.17	4.10(-2)	2.25	2.72(-2)	2.52
28	DX Del	1.85(-2)	5.93	7.52(-3)	7.87(-1)	3.17(-3)	3.51	7.16(-3)	4.22
29	V440 Sgr	7.39(-2)	2.35	4.61(-2)	4.95	2.90(-2)	1.25	2.68(-2)	3.77
30	SV Hya	3.74(-2)	4.15	2.06(-2)	4.23	1.19(-2)	4.26	1.09(-2)	4.32

TABLE 3—*Continued*

Star No.	Star Name	A_5	ϕ_5	A_6	ϕ_6	A_7	ϕ_7	A_8	ϕ_8
31	BB Pup	4.19(-2)	3.81	2.59(-2)	5.48	1.10(-2)	1.72	9.25(-3)	2.74
32	BR Aqr	6.42(-2)	9.66(-1)	3.65(-2)	2.15	2.77(-2)	2.96	1.31(-2)	4.21
33	FW Lup	6.91(-3)	5.59	2.54(-3)	9.07(-1)	3.51(-3)	3.33	3.04(-3)	4.00
34	ST Pic	8.53(-4)	3.52	7.12(-3)	1.22	4.58(-3)	1.05	3.13(-3)	1.60
35	AV Ser	5.85(-2)	3.86	3.22(-2)	1.79	2.28(-2)	5.76	1.62(-2)	4.21
36	V690 Sco	3.85(-2)	1.67	3.29(-2)	5.87(-3)	2.21(-2)	5.33	9.24(-3)	3.80
37	SS For	7.32(-2)	4.49	5.13(-2)	2.70	3.88(-2)	6.54(-1)	3.40(-2)	5.13
38	TY Aps	3.04(-2)	2.20	2.21(-2)	4.53	1.82(-2)	3.70(-1)	1.27(-2)	2.98
39	RZ Cet	2.79(-2)	3.85	2.13(-2)	4.06	1.18(-2)	4.67	1.01(-2)	4.79
40	V499 Cen	6.93(-2)	3.45	5.24(-2)	1.33	3.35(-2)	5.43	2.14(-2)	2.97
41	AN Ser	3.40(-2)	5.47	1.63(-2)	4.91	6.27(-3)	4.43	3.24(-3)	2.74
42	AF Vel	3.75(-2)	1.39	1.97(-2)	5.99	6.92(-3)	4.34	7.43(-3)	3.25
43	RY Psc	2.69(-2)	4.37	2.61(-2)	2.69	6.33(-3)	3.11	1.11(-2)	1.15
44	VY Lib	4.41(-2)	2.37	1.98(-2)	1.27	1.37(-2)	6.27	6.61(-3)	5.59
45	RR Cet	4.06(-2)	2.60	1.94(-2)	2.82	1.03(-2)	2.70	8.46(-3)	3.44
46	V452 Oph	5.07(-2)	1.82	2.41(-2)	2.22	1.68(-2)	2.20	7.44(-3)	2.09
47	RV Oct	5.00(-2)	3.76	3.52(-2)	4.02	3.36(-2)	4.02	1.41(-2)	4.64
48	TZ Aqr	2.23(-2)	1.55	1.49(-2)	3.73	4.30(-3)	6.23	6.39(-3)	4.08
49	WY Ant	4.17(-2)	1.43	2.58(-2)	2.40(-1)	5.70(-3)	4.96	1.13(-2)	4.17
50	V341 Aql	5.14(-2)	8.98(-1)	3.58(-2)	5.31	2.73(-2)	3.77	1.90(-2)	2.47
51	RX Eri	3.55(-2)	1.40	1.48(-2)	5.21	9.42(-3)	2.81	5.96(-3)	9.42(-1)
52	V413 CrA	1.56(-2)	1.58	7.13(-3)	3.56	7.25(-3)	5.57	7.00(-3)	5.62(-1)
53	RV Phe	1.75(-2)	5.35(-1)	1.03(-2)	1.08	5.19(-3)	6.23	6.18(-3)	1.18
54	TT Lyn	1.83(-2)	2.56	1.16(-2)	1.86	9.85(-3)	7.87(-1)	1.04(-2)	5.62(-1)
55	UU Cet	1.27(-2)	3.79	6.62(-3)	2.74	3.75(-3)	8.41(-1)	5.41(-3)	4.51
56	YY Tuc	5.25(-2)	2.46	2.91(-2)	3.50	2.60(-2)	5.10	1.66(-2)	2.82(-1)
57	FY Hya	7.20(-2)	5.43	3.93(-2)	2.39(-1)	1.73(-2)	1.17	1.84(-2)	1.01
58	V675 Sgr	5.01(-2)	4.50	2.30(-1)	2.63	1.12(-2)	6.18(-1)	9.03(-3)	4.87
59	UY Boo	6.04(-2)	1.56	3.26(-2)	2.97	1.63(-2)	3.94	3.59(-3)	4.94
60	X Ari	4.90(-2)	5.93(-1)	2.83(-2)	3.01	1.41(-2)	5.13	7.10(-3)	1.30
61	AV Vir	2.11(-2)	4.38	8.37(-3)	5.48	5.38(-2)	2.39(-1)	7.31(-3)	1.68
62	SU Dra	3.80(-2)	9.17(-1)	3.17(-2)	7.97(-1)	1.60(-2)	9.79(-1)	9.78(-3)	1.06
63	TV Leo	5.50(-2)	3.78	3.31(-2)	2.29(-1)	2.00(-2)	2.97	1.18(-2)	2.84(-1)
64	BO Aqr	4.02(-2)	3.93	2.67(-2)	4.30	1.28(-2)	4.81	5.87(-3)	4.57
65	TY Pav	2.57(-2)	3.56	1.33(-2)	1.41	5.98(-3)	6.01	8.50(-3)	4.38
66	VY Ser	1.73(-2)	3.78	1.10(-2)	5.82	8.22(-3)	2.02	6.81(-3)	3.65
67	X Crt	1.22(-2)	3.91	1.34(-2)	1.31	9.24(-3)	4.70	9.99(-3)	1.24
68	IU Car	4.52(-2)	6.22	2.52(-2)	2.15	1.16(-2)	4.31	6.95(-3)	7.63(-1)
69	AT Ser	3.40(-2)	2.31	1.21(-2)	2.31	1.16(-2)	2.82	9.00(-3)	3.58
70	XZ Cet	1.69(-3)	2.30	3.50(-3)	4.09	1.11(-3)	1.76	2.24(-3)	5.33

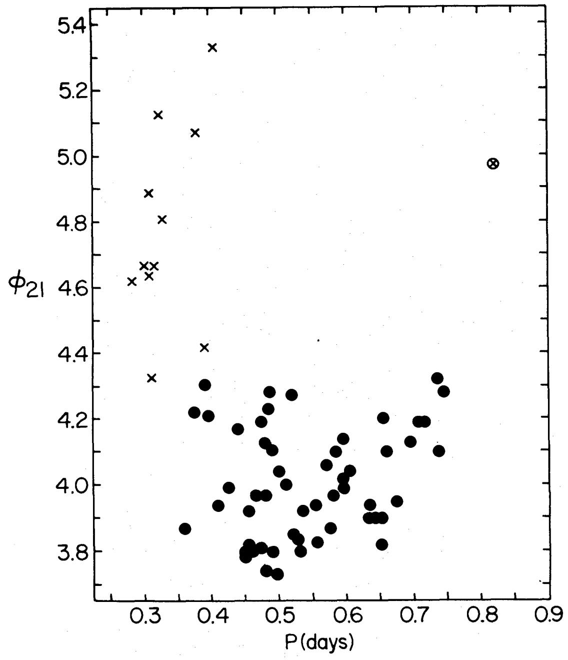

FIG. 1

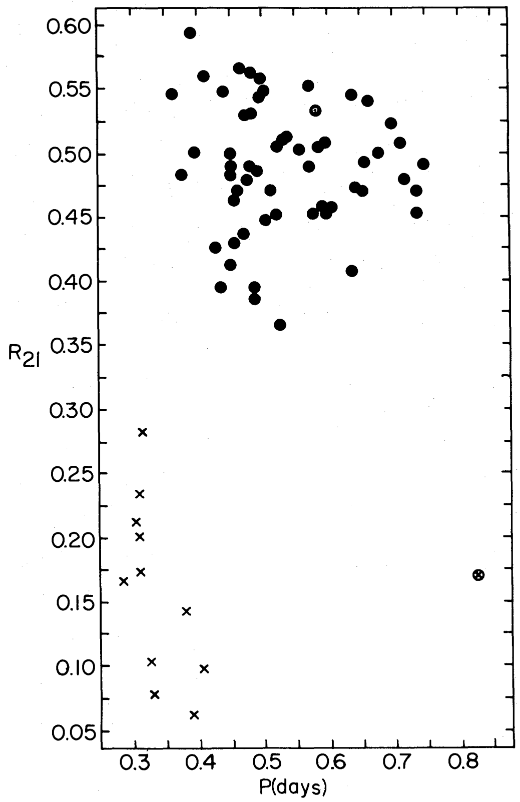

FIG. 2

FIG. 1.—ϕ_{21} vs. period. Crosses are Bailey type *c* stars; dots are type *ab*. The circle containing a cross is the variable XZ Ceti.
FIG. 2.—R_{21} vs. period. Notation as in Fig. 1.

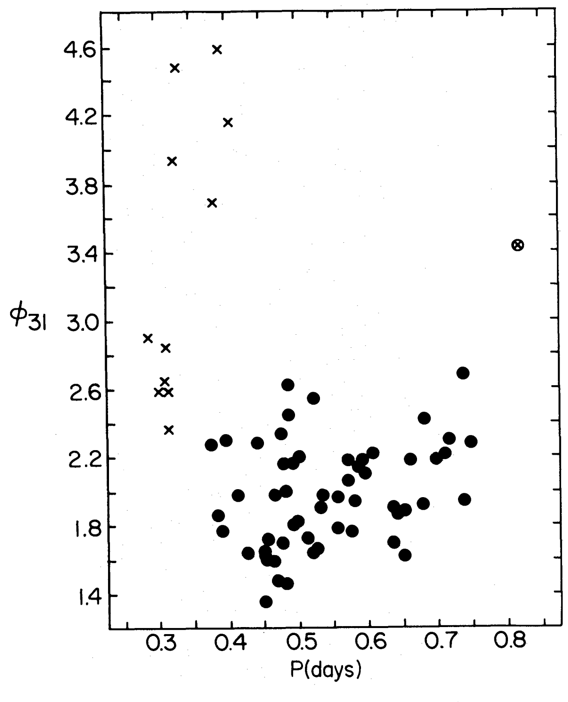

FIG. 3.—ϕ_{31} vs. period. Notation as in Fig. 1.

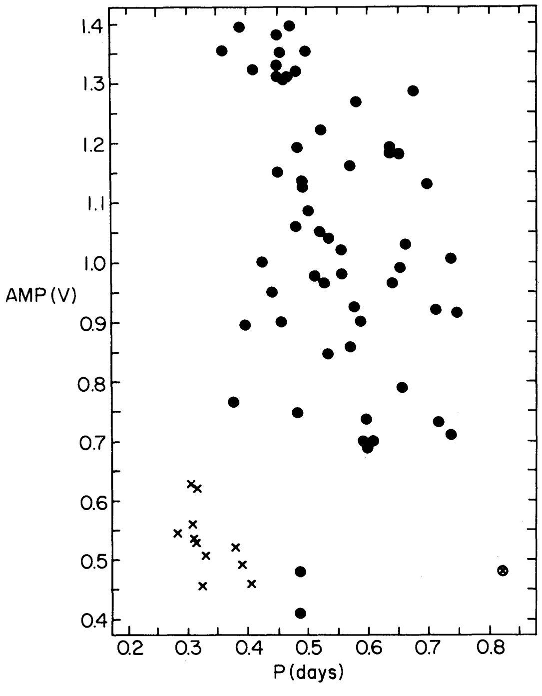

FIG. 4.—Amplitude vs. period. Notation as in Fig. 1.

resonance in the linear normal mode spectrum of these stars (Simon and Schmidt 1976). From the models of King, Cox, and Hodson (1981) it may be plausible to associate XZ Ceti with the resonance $P_2/P_0 = 0.5$, provided that the star is near the red edge of the instability strip and is very bright. Further observations will be necessary to determine if this is indeed the case.

On the other hand, if XZ Ceti is really a type *c* star, and thus presumably pulsating in the first overtone, it would have the longest period by far of any such known object. In that case, it could be a unique example of blue to red evolution on the horizontal branch (see Cox 1980). A handful of photometric light curves with good phase coverage for stars of period $P \gtrsim 0.75$ days would go a long way toward settling these matters. We strongly urge that such observations be undertaken.

We are very grateful to J. Lub for forwarding his observations to us. Without them, this investigation could not have been performed. One of us (N. R. S.) is pleased to acknowledge support from the National Science Foundation under grant AST 8105064.

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