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PERIODS OF 25 PULSATING RED GIANTS

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As stars expand and cool as red giants, they become pulsationally unstable. Initially, the amplitudes are a few hundredths to a few tenths of a magnitude, and the periods are days to weeks or more; these small-amplitude red variables (SARVs) are the subject of this paper. Later, the amplitude and period become much greater, and the star becomes a Mira star. This is one of a series of papers dealing with the search for, and study of SARVs; see Percy (1997) for a brief review.

Observations. The observations were obtained by the American Association of Variable Star Observers (AAVSO) photoelectric photometry program (Landis et al. 1992, Landis 2000). The results reported here are for two groups of stars: (i) those in Table 1 are stars in the general AAVSO PEP program which did not have sufficient measurements to be included in Percy et al. (1996); the data tend to be sparse at first, and then denser, as observers responded to the plea for more observations; (ii) those in Table 2 which are primarily stars which were assigned to specific observers (mostly RRT) as part of "Project SARV" (Percy et al. 1994). For both groups of stars, the measurements are made differentially in V only, relative to the comparison and check stars listed in the tables. They are corrected for differential extinction, and reduced to the standard V system using the catalogue values of the B - V colors. The observations are available from the AAVSO: 25 Birch Street, Cambridge MA 02138, USA; e-mail: aavso@aavso.org

Analysis. The measurements were analyzed using light curves, power spectra, and autocorrelation diagrams, as described by Percy et al. (1996), who showed that these three techniques are useful and complementary in the analysis of stars like these. Analysis of the stars in Table 1 was done by LK; that of the stars in Table 2 was done by HD.

Results. The results are summarized in Table 1 and 2, which list the various designations of each star, the spectral type (from either the *Hipparcos Catalogue* (Perryman et al. 1997; hereinafter P97) or the *Bright Star Catalogue*), the amplitude ΔV , the time span of the data Δt in days (ending about JD 2451000), and the period of variability: more certain periods are given in bold-face type; less certain periods are denoted by a colon. A few of the stars were observed independently with an Automatic Photometric Telescope (Percy et al. 2000). Further notes are given below:

Name	НD	SpT	Comp and	ΔV	Δt	Period
Ivanie	ШD		Check (HD)		(days)	(days)
T Cet	1760	M5/6Ib-II	2475, 1343	0.80	3800	110:, 280:
EG And	4174	M2e	3765, 4479	0.27	5550	29,240
AK Hya	73844	M6III	$73603, \ 74991$	1.16	3100	50::
TV UMa	102159	M4III	101978,102941	0.72	5800	600
GK Com	104207	M4III	104290,102715	0.32	5300	
SW Vir	114961	M7III	114866, 114783	1.85	5700	155
FH Vir	115322	M6III	115885, 114174	1.19	5650	72, 280
EV Vir	124304	M3III	124401, 124106	0.52	5550	19.5,57
$ au^4$ Ser	139216	M5II-III	140027, 139074	1.08	5750	110 + long
AZ Dra	151481	M2III	150010, 151541	0.55	1020	352
V973 Cyg	186776	M3III	187523, 186619	0.40	1950	35,376
V1070 Cyg	203712	M7III	203713, 203857	0.83	4200	110, 470

Table 1: Program stars and results

Notes on Stars in Table 1: T Cet: unsolved, literature period 158.9 days (P97). EG And: unsolved (P97); periods 29 and 242 days (Percy et al. 2000). AK Hya: unsolved, literature period 75 days (P97). TV UMa: unsolved, literature period 42 days (P97). GK Com: unsolved, literature period 50 days (P97). SW Vir: period 153.6 days, literature period 150 days (P97); period 153.8 days (Percy et al. 2000). FH Vir: unsolved, literature period 70 days (P97). EV Vir: unsolved, literature period 120 days (P97). τ^4 Ser: unsolved, literature period 100 days (P97). AZ Dra: unsolved, no literature period (P97). V973 Cyg: unsolved, literature period 40 days (P97). V1070 Cyg: unsolved, literature period 73.5 days; complex variability with possible period of 60 days (Percy et al. 2000).

HR	Name	SpT	Comp and	ΔV	Δt	Period
1110	rtanio	SPI	Check (HR)	<u> </u>	(days)	(days)
211	NSV 00293	M4III	225, 213	0.22	1950	$12? \ 32? \ 40?$
284	WW Psc	M2III	$294, \ \ 307$	0.23	1900	25, 300
648	$CSV \ 100168$	M0III	$624, \ \ 609$	0.14	1950	32:, 275:
2286	$\mu {\rm ~Gem}$	M3III	2230, 2185	0.23	2400	29
2999	NSV 03721	M3III	3522, 3540	0.13	2400	22:, 360
3521	BO Cnc	M3III	3522, 3540	0.26	1950	27, 270
4267	VY Leo	M5III	4207, 4201	0.75	2650	48, 500
4483	ω Vir	M4III	4559, 4515	0.28	2250	30, 275
5331	FS Vir	M4III	$5283,\ 5307$	0.18	1850	20, 250
5352	CY Boo	M3III	5254, 5243	0.10	1800	23, 350:
6543	V642 Her	M4III	6542,6577	0.29	2650	26 and/or 32
6815	V669 Her	M3III	6768,6775	0.17	2650	27
7009	XY Lyr	M4.5II	$7017,\ 7019$	0.55	1575	120

Table 2: Program stars and results

Notes on Stars in Table 2: These were classified as "unsolved" by P97 unless otherwise noted. HR 211: very poor distribution of observations; Thompson (1999) found a time scale of about a month from a subset of these data, and from *Hipparcos* epoch photometry. HR 648: very sparse observations; no obvious time scale. HR 2286:

period 27 days plus long period (Percy et al. 2000). **HR 2999:** no obvious short period. **HR 4267:** period 46.34 days (P97). **HR 6543:** period 25.6 days, plus 500-1500 days (Percy et al. 2000); period 25 days (Percy et al. 1994); literature period 12 days (P97). **HR 6815:** period about 20 days (Percy et al. 1994); Thompson (1997) found a time scale of just over 20 days from a subset of these data.

Discussion. Previous papers in this series (see Percy 1997 for a list and review of these) have revealed both short (20–200 days) and long (hundreds or thousands of days) periods in SARVs. Note that most of the stars in Tables 1 and 2 have a period in the range of 20–50 days; these short periods are apparently radial pulsation periods (Percy & Parkes 1998). The nature of the long periods is unclear; two recent suggestions have been (i) the rotation of a non-uniform star (Cummings 1999) and (ii) a convectively induced oscillatory thermal mode (Wood 2000). The present results add to our database of periods of SARVs, which will be used to study the nature and systematics of both long and short periods.

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