Studies of RV Tauri and SRD Variables

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Abstract AAVSO visual and Johnson V observations of 42 RV Tauri and 30 yellow semiregular (SRD) variables have been time-series analyzed with the AAVSO VSTAR package. The DCDFT routine was used to determine periods and mean amplitudes, and the WWZ (wavelet) routine was used to study changes in the amplitudes of these stars. For almost half of the stars, improved periods and/or classifications were obtained. For others, existing classifications and periods were confirmed or supported. As was previously found for a subset of RV and SRD stars, the pulsation amplitudes vary by factors of up to 10, on median time scales of about 22 pulsation periods for the RV stars, and about 25 pulsation periods for the SRD stars; these two values are not significantly different. This behavior is consistent with that of pulsating red giants and supergiants. The cause of the pulsation amplitude variations remains unknown.

1. Introduction

RV Tauri (RV) stars are low-mass yellow supergiants which show alternating deep and shallow minima to a greater or lesser extent. RVA stars have constant mean magnitude. RVB stars vary slowly and periodically in mean magnitude; they have a "long secondary period" (LSP). SRD stars are semiregular yellow supergiants. Confusingly, RV stars are clsssified, spectroscopically, as type A (G and K type, probably old Population I), type B (Fp type, with CH and CN bands of normal strength), and type C (Fp type with weak CH and CN bands, Population II) (Preston *et al.* 1963).

This is one in a series of papers which, thanks to AAVSO observations of these stars over many decades, explores the nature of and relation between these classes, and with other pulsating stars such as Type I and II Cepheids, and pulsating red giants: Percy and Mohammed (2004), Percy and Ursprung (2006), and especially Percy and Kim (2014). It also continues our studies of pulsation amplitude variations in these stars.

2. Data and analysis

This study used visual and Johnson V observations from the AAVSO International Database (AID; Kafka 2015) of the RV and SRD stars listed in the tables. See sections 3.5 and 3.6 for remarks on some of these. The stars were chosen from a list, dating back some years, of the stars on the AAVSO visual observing program. The data extend for typically 10,000–30,000 days; not all the stars have the same length of dataset. Percy and Abachi (2013) discussed some of the limitations of visual data which must be kept in mind when time-series analyzing the observations and interpreting the results. In particular, some of the stars have pronounced seasonal gaps in the data, which can produce "alias" periods, and some difficulty in the wavelet analysis.

The data, extending over the range of Julian Date given in the tables, were analyzed with the AAVSO's VSTAR time-series analysis package (Benn 2013), especially the Fourier (DCDFT) analysis and wavelet (WWZ) analysis routines. Periods, and their mean amplitudes, were first determined using the DCDFT routine. The results are given in Tables 1 and 3. The WWZ (wavelet) routine was then used to study the changes in amplitude for the stars with sufficient data. Percy and Kim (2014) have already done this for a subset of the stars in the tables. See that paper for a fuller description of how the analysis was done, and the challenges of doing so. For the wavelet analysis, the default values were used for the decay time c (0.001) and time division t (50 days). The results are sensitive to the former, but not to the latter.

3. Results

See sections 3.5 and 3.6 for notes on individual stars. See the papers by Percy and Abachi (2013) and Percy and Kim (2014) for examples of DCDFT and wavelet plots.

3.1. Periods of RV stars

Table 1 contains the results of the period and mean amplitude determinations for the RV Tauri stars. The columns list the *General Catalogue of Variable Stars* (GCVS; Samus *et al.* 2012)) classification and period P in days, and the periods and amplitudes that were obtained from the AAVSO visual and V observations. If the periods and/or classification differed significantly from the GCVS information, the star name is given in bold face, and the change is noted in section 3.5.

3.2. Amplitude variations in RV stars

Table 2 contains the results of the WWZ amplitude-variability determinations for the RV Tauri stars, for those stars which had sufficient data for wavelet analysis. The columns list the period P used, the range of JD, the range of amplitude, the number N of cycles of amplitude increase and decrease, and the value of L/P where L is the average length of the cycles, and P is the pulsation period. For the stars marked with an asterisk, the results are taken from Percy and Kim (2014). See Percy and Abachi (2013) for a discussion of the determination of N, L, and L/P, and the uncertainties of these. The values of L/P do not depend significantly on the exact value of P used, or whether the "full" period or "half" period is used (Percy and Kim 2014).

Table 1. Period determination for RV Tauri stars.

*Star**	*Type*	*P (d)*	*Filter*	*Period (Amplitude) (days)*
DY Aql	RV	131.42	vis	65.68 (0.33)
EZ Aql	RVA	38.64	vis	19.37 (0.57), 38.73 (0.25)
IS Aur	SR	76.5	V	75.26 (0.80)
TW Cam	RVB	87.22	vis	43.48 (0.08), 669.7 (0.06)
			V	43.25 (0.30)
RX Cap	RV	67.92	vis	140.33 (0.11), 67.93 (0.11)
IW Car	RVB	67.5	vis	36.32: (0.01), 67.55: (0.02), 1433 (0.31)
EQ Cas	RVA	58.34	vis	58.23 (0.16), 29.12 (0.33)
			V	58.21 (0.28), 29.11 (0.45)
RU Cen	—	64.7	vis	32.26 (0.28), 64.7 (0.12)
			V	32.3 (0.41)
SX Cen	RVB	32.9	vis	16.44 (0.29), 31.05 (0.18), 603.2 (0.74)
BI Cep	RVA	212	V	209.8 (0.22)
DF Cyg	RVB	49.808	vis	24.92 (0.21), 50.2 (0.08), 778.4 (1.12)
			V	781.8 (1.31)
GK Cyg	RV	79.75	V	79.25 (0.33), 39.71 (0.34)
V360 Cyg	RVA	70.39	vis	35.18 (0.35), 70.43 (0.09)
SS Gem	RVA	89.31	vis	44.57 (0.21), 89.14 (0.21)
			V	same
SU Gem	RVB	50.0	vis	24.97 (0.24), 50.06: (0.08), 681.66 (0.98)
BG Gem	RV	60	V	91.6 (0.11), 45.73 (0.28)
AC Her	RVA	75.01	vis	75.41 (0.20), 37.70 (0.33)
BT Lac	RVB	40.50	V	79.7 (0.40), 652 (0.89)
EG Lyr	RVB	236	vis	220.61 (0.24)
EP Lyr	RVB	83.34	vis	41.49 (0.22), 82.98 (0.21)
V443 Lyr	RV	—	V	51.2 (0.24) uncertain
U Mon	RVB	91.32	vis	45.73 (0.21), 2427 (0.32)
			V	46.05 (0.24), 91.5 (0.16)
HQ Mon	RV	65	V	25–35 (0.15)
TT Oph	RVA	61.08	vis	30.51 (0.32)
			V	30.50 (0.55), 61.58 (0.19)
TX Oph	RVA	135	vis	134.55 (0.12), 67.62 (0.12)
UZ Oph	RVA	87.44	vis	43.68 (0.36), 88 ± (0.17)
CT Ori	RV	135.52	vis	33.6 (0.14), 67.2 (0.14)
			V	33.59 (0.18), 66.95 (0.12)
DY Ori	RV	60.26	vis	30–40 (0.16)
			V	30.2 (0.16), 60.74 (0.12)
V360 Peg	RV	—		no result
TX Per	RVA	78	vis	76.40 (0.15)
			V	75.7 (0.42)
AR Pup	RVB	74.58	vis	38.35 (0.13), 75.62 (0.03), 1194 (0.31)
TW Ret	RV	—	V	242 (0.80), 121 (0.47)
AR Sgr	RVA	87.87	vis	86.83 (0.18), 43.20 (0.28)
			V	87.93 (0.46), 43.89 (0.46)
AZ Sgr	RVA	113.6	vis	112.82 (0.17), 56.57 (0.19)
R Sge	RVB	70.77	vis	35.39 (0.18), 70.80 (0.10)
			V	35.5 (0.33), 71.0 (0.23)
AI Sco	RVB	71.0		35.82 (0.22), 71± (0.03), 977.6 (0.88)
R Sct	RVA	146.5	vis	143.85 (0.19), 70.93 (0.17)
RV Tau	RVB	78.73	vis	39.24 (0.27), 78.81 (0.08)
			V	39.22 (0.49), 78.32 (0.23)
DZ UMa	RVB:	—	vis	70.52 (0.29), 507.42 (0.19)
CE Vir	RV	67	vis	70 ± (0.11)
			V	70 ± (0.20)
V Vul	RVA	75.7	vis	76.23 (0.17), 38.08 (0.13)
NSV 7378	RV	—	vis:	no result

**If the periods and/or classification differed significantly from the GCVS information, the star name is given in bold face, and the change is noted in section 3.5.*

Table 2. Amplitude variability of RV Tauri stars.

Star	P (d)	JD range	A range	N	L/P
DY Aql	131.42	2442000–2457250	0.2–0.7	6	19
TW Cam	87.22	2442000–2457250	0.10–0.40	12	15
RX Cap	67.92	2443000–2453000	0.22–0.52	9	16
IW Car*	71.96	2446037–2456646	0.05–0.24	8	18
EQ Cas	58.34	2446000–2457250	0.20–0.55	5.5	35
RU Cen	64.727	2450000–2453250	0.08–0.70	3.5	32
DF Cyg*	24.91	2441000–2456600	0.20–0.86	20	31
GK Cyg	79.75	2445000–2456000	0.2–0.7	7	20
V360 Cyg	70.39	2445000–2457250	0.05–0.40	10	18
SS Gem	89.14	2441000–2457250	0.13–0.35	10	18
SU Gem*	24.98	2446000–2456250	0.00–1.35	15	27
AC Her*	37.69	2435500–2456600	0.28–0.49	12.5	45
EP Lyr	83.34	2445000–2457250	0.11–0.36	7:	21
U Mon	91.32	2433000–2457250	0.05–0.35	13	20
TT Oph	30.51	2427946–2456615	0.25–0.76	39	24
TX Oph	135	2427500–2457250	0.05–0.56	7.75	28
UZ Oph	43.71	2445500–2456626	0.20–0.70	9.5	27
CT Ori	67.29	2446500–2457250	0.06–0.36	9	18
TX Per*	76.38	2427964–2456654	0.12–0.75	7.5	50
AR Pup	74.58	2446000–2457250	0.04–0.22	8	19
AR Sgr	87.87	2449000–2457250	0.12–0.37	7:	13
AZ Sgr	113.6	2451000–2457250	0.13–0.36	1.5	37
R Sge	70.77	2420000–2457250	0.05–0.50	16	35
AI Sco*	35.76	2445000–2455750	0.15–1.10	11	27
R Sct	146.5	2420000–2457259	0.05–0.85	9.5	27
RV Tau	78.73	2435000–2457250	0.03–0.28	17.5	16
V Vul*	76.31	2446000–2456649	0.20–0.35	5.5	22

** See note in section 3.5.*

3.3. Periods of SRD stars

Table 3 contains the results of the period and mean amplitude determination for the SRD stars. If the period and/or classification differ significantly from the GCVS information, the star name is given in bold face, and the differences are noted in section 3.6.

3.4. Amplitude Variations in SRD stars

Table 4 contains the results of the WWZ amplitude-variability determinations for the SRD stars. See section 3.2 for further information.

3.5. Notes on individual RVT stars

These notes are given in the same order as the stars are listed in Table 1. Unless indicated, there is no evidence for an LSP in RV stars which were classified in the GCVS as RVA.

DY Aql: The GCVS period of 131 days is present, but at the noise level; the strongest period is 65.68 days, with an amplitude of 0.33. May not be an RV star.

IS Aur: This star is an M2III SR variable with a period of 75.26 days and a V amplitude of 0.80; not an RV or SRD star.

TW Cam: There is an LSP of 670 days (amplitude 0.06), supporting the RVB classification, but the present analysis does not detect both P and P/2.

RX Cap: The phase curve for 67.93 days has two unequal minima, confirming the RV classification, but there is no LSP, therefore an RVA star.

IW Car: The LSP of 1433 days (amplitude 0.31) confirms the RVB classification.

RU Cen: The data are very sparse. A period of 64.7 days produces a phase curve with two unequal minima, and there is an LSP of 561 days (amplitude 0.19), which supports an RVB classification. This star is a 1489-day binary (Gezer *et al.* 2015); that period is not present in the DCDFT spectrum. The amplitude of the pulsation seems to vary with the LSP.

SX Cen: The LSP of 603 days (amplitude 0.74) confirms the RVB classification. This star is a 600-day binary (Gezer *et al.* 2015).

BI Cep: The visual data are sparse. The (also sparse) V data give a period of 209.8 days, close to the GCVS period of 212 days.

DF Cyg: The LSP of 780 days (amplitude 1.12) confirms the RVB classification.

GK Cyg: The sparse visual data show many peaks of comparable amplitude. The V data show peaks at 79.25 and 39.71 days, both with amplitudes of 0.33; the phase curve for the longer period has two minima with unequal depth, confirming the RV classification, but there is no LSP, therefore the star is RVA.

SU Gem: The LSP of 681.66 days (amplitude 0.98) confirms the RVB classification.

BG Gem: Only V data are available. A period of 91.6 days gives a classic RV phase curve, with two unequal minima, confirming the RV classification. There is no evidence of an LSP so this star is probably RVA.

AC Her: This star is a 1196-day binary (Gezer *et al.* 2015). A period of 1,194 days is present in the DCDFT spectrum, but with an amplitude of only 0.0165 mag.; there are higher long-period peaks in the spectrum.

BT Lac: The LSP of 652 days (amplitude 0.89) confirms the RVB classification. The visual data are sparse. In the V data, the half-period is not resolvable from the noise.

EG Lyr: This star is an SRA/SRB (M-type) star; the (sparse) visual data give a period of 220.61 days, which may be inconsistent with the GCVS period of 236 days.

EP Lyr: Zsoldos (1995) found no periodic variation in mean magnitude; the present data support this conclusion. The star is RVA, not RVB.

V443 Lyr: There are no convincing periods in the AAVSO data.

U Mon: The LSP of 2427 days (amplitude 0.20) confirms the RVB classification. This star is a 2597-day binary (Gezer *et al.* 2015).

CT Ori: The data are rather sparse. A period of 67.29 days produces a phase curve with two unequal minima, and there is no conspicuous LSP, which supports an RVA classification. The GCVS period of 135.52 days is not found.

DY Ori: The data are sparse. In the visual and V data, periods of 60.7 and 30.2 days are present, but not conspicuous. The former period produces a phase curve with two unequal minima, and there is no obvious LSP, which supports an RVA classification.

V360 Peg: There are no convincing periods in the AAVSO data.

TX Per: Only one period (75.7 days) is clearly present, but there is some weak evidence for a 37.5-day period, so the classification of this star is uncertain.

Table 3. Period determination for SRD stars.

Star*	Type	P (d)	Filter	Period (Amplitude) (days)
WY And	SRD	109.65	vis	108.4 (0.33)
			V	108.15 (0.28)
TX Aql	SRD	35	vis	34.75 (0.15)
			V	33.7:
Z Aur	SRD	111.5	vis	110.4 (0.25)
			V	110.2 (0.61)
AG Aur	SRD	99	vis	96.2 (0.30)
			V	96.2 (0.29)
CO Aur	Cep	1.78	vis	1.783027 (0.09)
UY CMa	SRD	114.6	vis	113.9 (0.11)
			V	114.1 (0.36)
RU Cep	SRD	109	vis	108.9 (0.06), 520.8 (0.10)
RX Cep	SRD	55	vis	constant
TZ Cep	SRD	83.0	vis	82.4 (0.48)
RV Col	SRD	105.7	vis	106.1 (0.23)
			V	101.36: (0.21)
AV Cyg	SRD	89.22	vis	88.1 (0.22)
			V	88.14 (0.19)
V395 Cyg	SRD:	40.5	V	40.1 (0.07), 32.8 (0.06) not aliases
VW Dra	SRD:	170	vis	not variable
IS Gem	SRC	47	vis, V	constant
SX Her	SRD	102.9	vis	103.5 (0.17)
			V	102.9 (0.18)
UU Her	SRD	80.1	vis	72.8 (0.02), 44.9 (0.03)
			V	71.2 (0.10), 44.9 (0.10)
DE Her	SRD	165.2	vis	172.76 (0.33)
			V	173.1 (0.57)
V441 Her	SRD	68	vis	68.25/71.8 (0.06)
			V	64.98 (0.02) / 79.04 (0.02) aliases
RS Lac	SRD	237.26	vis	237.74 (0.72)
			V	237.17 (0.45)
SX Lac	SRD	190.0	vis	195.47 (0.10)
AB Leo	SRD	130.2	vis	103.1 (0.16)
			V	103.1 (0.22)
W LMi	SRD	117.2	vis	116.8 (0.80)
			V	116.6 (0.90)
V564 Oph	SRD	70.325	vis	73.1 (0.12)
GT Ori	SRD	86	vis	no periods
TV Per	SRD	358	vis	372.4 (0.48)
RX Ret	SRD	—	vis	74–79 (0.12)
			V	66–69 (0.35)
BM Sco	SRD	815	vis	382 (0.20), alias of LSP?
LR Sco	SRD	104.4	vis (WWZ)	possibly 70, 105, 140
WW Tau	SRD	116.4	vis	114.5 (0.47), 640–690 (0.22)
SV UMa	SRD	76	vis, V:	60–100

**If the periods and/or classification differed significantly from the GCVS information, the star name is given in bold face, and the change is noted in section 3.6.*

AR Pup: The LSP of 1194 days (amplitude 0.31) confirms the RVB classification.

TW Ret: There are no visual data. The V data suggest periods of 242 (amplitude 0.80) and 121 (amplitude 0.47) days, supporting the RV classification. No information about an LSP is found.

R Sge: The LSP of 1125 days (amplitude 0.11) confirms the RVB classification.

AI Sco: The LSP of 977.6 days (amplitude 0.88) confirms the RVB classification.

DZ UMa: The LSP of 507.4 days (amplitude 0.19) confirms the RVB classification; the GCVS classification is RVB:.

CE Vir: The data are sparse. There is a period of about 70 days, but not enough evidence to classify the star as RV or SRD. There are slow variations, but they are not necessarily periodic.

NSV 7378: There are no conspicuous periods in the AAVSO data.

3.6. Notes on individual SRD stars

These are given in the same order as in Table 3. They contain information about e.g. the presence of an LSP, or a proposed change to the GCVS classification.

WY And: There is a large gap in the data; only the most recent data are suitable for wavelet analysis. The periods in the AAVSO data, 108.4 days in the visual data, 108.15 days in the V data, differ slightly from the GCVS period of 109.65 days.

TX Aql: The 34.75-day period in the AAVSO data is consistent with the GCVS period of 35 days.

Z Aur: This well-studied star alternates between periods of

Table 4. Amplitude variability of SRD stars.

Star	P (d)	JD range	A range	N	L/P
WY And	109.65	2453000–2457250	0.20–0.40	1.5	26
TX Aql	35	2423910–2425568	0.06–0.28	1.5:	32
Z Aur*	110.40	2423000–2456651	0.20–0.76	15	20
AG Aur*	96.13	2441000–2456600	0.15–0.78	11	15
UY CMa	114.6	2435000–2457250	0.03–0.39	8	24
RU Cep	109	2432000–2457250	0.03–0.25	6±	39
TZ Cep*	82.44	2451426–2456635	0.33–0.76	2.2	29
RV Col	105.7	2440000–2457250	0.20–0.45	9:	19
AV Cyg*	87.97	2429012–2456630	0.11–0.57	9	35
SX Her*	103.50	2425000–2456631	0.08–0.44	6	47
UU Her*	44.93	2432000–2456622	0.02–0.18	15	37
DE Her*	173.10	2442000–2456622	0.13–0.64	1.5	56
V441 Her	68	2447000–2457250	0.02–0.07	7.5	20
RS Lac*	237.57	2427592–2456635	0.24–1.02	3.5	35
SX Lac*	195.48	2446000–2456282	0.10–0.17	3.75	14
AB Leo	130.2	2432000–2457250	0.05–0.50	10	25
W LMi	117.2	2440000–2457250	0.73–1.05	7	21
V564 Oph	70.325	2449000–2457250	0.10–0.43	4.5	25
TV Per	358	2437000–2457250	0.08–0.40	2.3	24
RX Ret	(75)	2440000–2457250	0.13–0.70	12	18

* *See note in section 3.6.*

110.4 and 133.6 days. It is an M star, and therefore SRA/SRB classification.

AG Aur: The visual and V data support a period of 96.16 days, in agreement with an earlier GCVS period, but not in agreement with the current GCVS period of 99 days.

CO Aur: This star is a Cepheid with a period of 1.783027 days, not an SRD star.

UY CMa: The DCDFT spectrum shows periods of 113.9 (visual) or 114.1 (V) days. There are very slow variations in mean magnitude.

RU Cep: There is a possible LSP of 520.8 days, with visual amplitude 0.06.

RX Cep: There are no peaks higher than 0.02 mag. The GCVS period of 55 days has an amplitude 0.003. Probably not an SRD star.

TZ Cep: There is a large gap in the middle of the dataset.

RV Col: The visual data show possible periods of 106.1 and 149.8 days, with comparable amplitudes; these periods are aliases. The limited V data and the period in the literature support the shorter period.

AV Cyg: The periods (amplitudes) in the AAVSO data are visual: 88.1 (0.22) days, V: 88.14 (0.19) days. Both differ slightly from the GCVS period of 89.22 days.

V395 Cyg: There are peaks at 40.1 and 32.8 days (not aliases) in the V data. No peaks stand out in the visual data. The data are sparse, but the SRD classification is probably correct.

VW Dra: There are no peaks higher than 0.02 mag.

IS Gem: The amplitude is less than 0.01; there is no evidence for the GCVS period of 47 days.

UU Her: This star is well known to switch between periods of about 72 and 45 days. The AAVSO visual data show periods (amplitudes) of 72.8 (0.02) and 44.9 (0.03) days, the V data 71.2 (0.10) and 44.9 (0.10) days, none of them agreeing with the GCVS period of 80.1 days.

DE Her: The periods (amplitudes) in the AAVSO data are visual: 172.76 (0.33) days, V: 173.1 (0.57) days. These are slightly different from the GCVS period of 165.2 days.

V441 Her (89 Her): This photoelectrically-well-studied star shows periods of 64.98 or 79.04 days in the visual data (these periods are aliases) and 71.8 days in the V data, in each case with a small amplitude. The GCVS period is 68 days. Fernie and Seager (1995), from several years of photoelectric data, obtain a period of 63.50 ± 0.48 days. The star is also a 288.4-day binary.

SX Lac: The 195.47-day period in the AAVSO visual data differs slightly from the GCVS period of 190.0 days.

AB Leo: The results support a period of about 103 days, not the GCVS period of 130.2 days.

V564 Oph: The only peak above the noise level is 73.1 days, which is slightly different from the GCVS period of 70.325 days. The data are sparse.

GT Ori: Although the data are plentiful, they show no obvious periods, including the GCVS period of 86 days, which does not produce a significant phase curve. The SRD classification cannot be confirmed.

TV Per: There are very slow variations in mean magnitude.

RX Ret: In addition to the pulsation period of 79.1 days, there is a possible LSP of 736 days, visual amplitude 0.13, but the noise level is high. For the wavelet analysis, we used a period of 75 days, proposed by the RASNZ.

BM Sco: The light curve and DCDFT spectrum shows a time scale of several thousand (nominally 8,000) days, and a 382-day alias of this. There is no evidence for the GCVS period of 815 days. The SRD classification is therefore doubtful.

LR Sco: The DCDFT spectrum does not show any peaks in the visual data greater than the noise level of 0.10, and the phase diagram for the GCVS period of 104.4 days is not convincing. Wavelet analysis suggests that there may be periods of about 70, 105, and 140 days, with variable amplitudes, but the classification is uncertain.

WW Tau: There are possible LSPs of 640–690 days, with visual amplitude 0.22. There is a large gap in the middle of the dataset.

SV UMa: There are several peaks between 60 and 100 days; none stand out, not even the GCVS period of 76 days, so the star's classification is uncertain.

4. Discussion

The classification of low-mass pulsating yellow supergiants is complicated by the fact that the RV phenomenon—alternating deep and shallow minima—is not regular; in fact, there may be a continuous spectrum of behavior from RV to SRD (Percy 1993; Percy and Mohammed 2004). Therefore the classifications in Tables 1 and 3 and in sections 3.5 and 3.6 are uncertain, to a greater or lesser extent. Many previous classifications (and periods) were based on fragmentary data. The systematic, sustained AAVSO data provide an improvement. It would probably require an almost-infinite set of almost-perfect data to make a firm classification. The AAVSO data do make it possible to investigate the long-term changes in pulsation amplitude which were found in the present study and in previous ones.

The cause of these variations is not known, so the results of this paper make a significant contribution to the understanding of stellar pulsation.

As for the nature of RV stars, and the cause of the RVB phenomenon, much has been learned in the last two decades, thanks especially to multi-technique, multi-wavelength studies, notably spectroscopy, and infrared photometry. Van Winckel *et al.* (1999) propose that RVB stars are binaries, with a circumbinary dusty disc. If the disc is seen at high inclination, that is, almost edge-on, then long-period variability will occur because of periodic extinction during the orbital motion. Percy (1993) also proposed a binary model for the RVB phenomenon on the basis of the long-term light curve of U Mon.

Gezer *et al.* (2015) have recently published a comprehensive study of RVA and RVB stars, using new infrared photometry, combined with existing spectroscopic data. They note that (i) all confirmed binary RV stars have infrared properties indicative of a disc, and (ii) all RVB stars in their sample also have infrared properties of a disc. If the long secondary periods of the RVB stars reflect their orbital motion, then the improved photometric periods and classifications in this paper will be useful to spectroscopists; Gezer *et al.* (2015) stress that "more radial velocity monitoring is needed for all RV and RVB objects to test their binary nature." Binaries in our sample include RU Cen (1,489 days), SX Cen (600 days), AC Her (1,196 days), and U Mon (2597 days) (Gezer *et al.* 2015).

In their Tables 4 and 5, Gezer *et al.* (2015) list the spectroscopic types and [Fe/H] metal abundances of the stars in their sample. Of the (photometric) RVA stars, 8/10 are spectroscopic type A. Of the (photometric) RVB stars, 8/12 are spectroscopic type A. These fractions are not significantly different. Only one star—the RVA star V360 Cyg—is spectroscopic type C. The distributions of the [Fe/H] values of the RVA and RVB stars overlap but, on average, are lower for the RVA stars. See Gezer *et al.* (2015) for a detailed discussion of the complex processes which affect the chemical abundances in these stars.

It is heartening to know that there is still science to be extracted from the visual observations in the AAVSO International Database. They are unique in providing a window on the long-term behavior of stars such as RV, SRD (and pulsating red giants).

5. Conclusions

Using AAVSO visual and V observations, it is possible to refine the classifications and periods of many RV and SRD stars, and to confirm or support the classifications and periods of many others. For stars which have sufficiently dense and sustained data, wavelet analysis has been used to show that the pulsation amplitudes of these stars vary by up to a factor of ten, on time scales of 20–25 pulsation periods. Pulsating red giants and supergiants show this same behavior. The cause of these amplitude variations remains unknown.

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