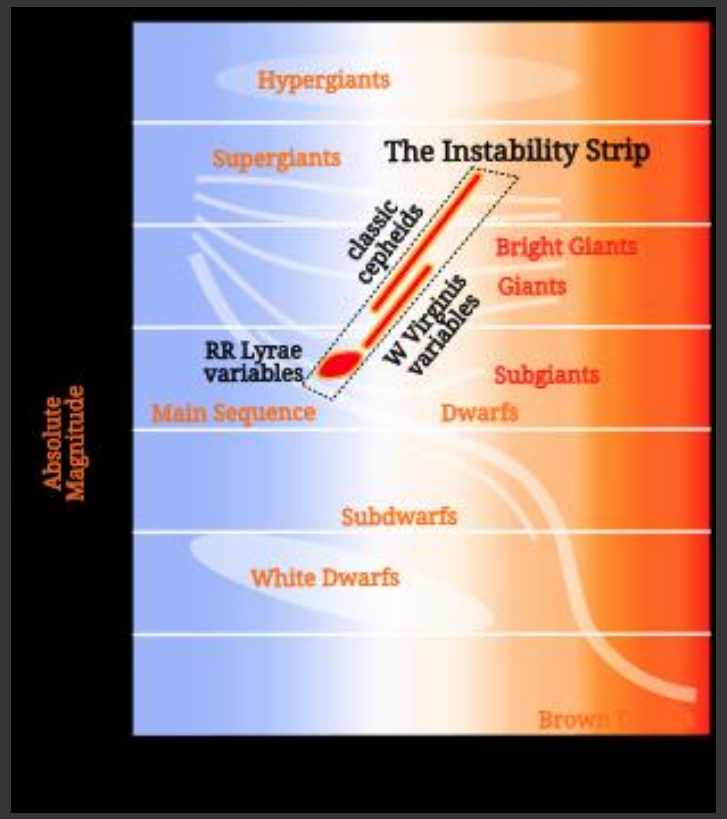
Étude des étoiles variables de type RR Lyre dans l'amas globulaire Messier 3.

Introduction



Référence: Wikipédia

Bande d’instabilité du diagramme HR

Vieille étoiles

0.5 masse du Soleil

Amas globulaires

Période entre 0.2 et 1.1 jours

Chandelle galactique

Référence: Wikipédia

Williamina Fleming
Astronome amérinaine
RR Lyrae
Harvard 1901

Chandelle galactique – Module de distance

Différence entre la magnitude apparente m et la magnitude absolue M d'un astre.

$$m - M = -5 + 5 \log_{10} d$$

m: magnitude apparente
M: magnitude absolue
d: distance (pc)

$$m - M = -5 + 5 \log_{10} d$$

$$d = 10^{(m/5+M)}$$

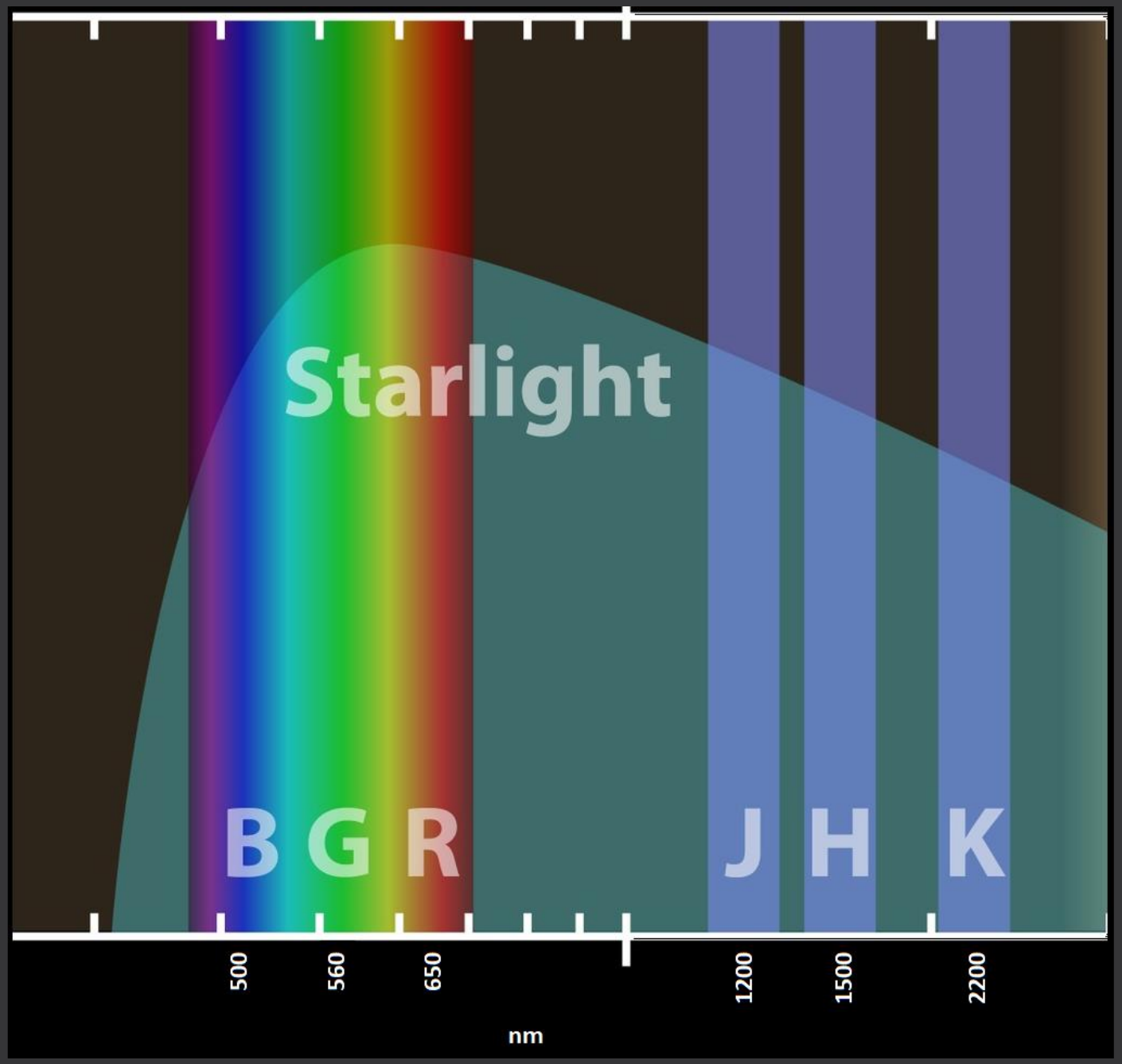
$M = 0.85$, $m = 15.85$ (Messier 3)

$$d = 10^{(15.85/5 + 0.85)}$$

$$d = 10^{4.02}$$

$d = 10\,471$ pc (34 152 a.l.)

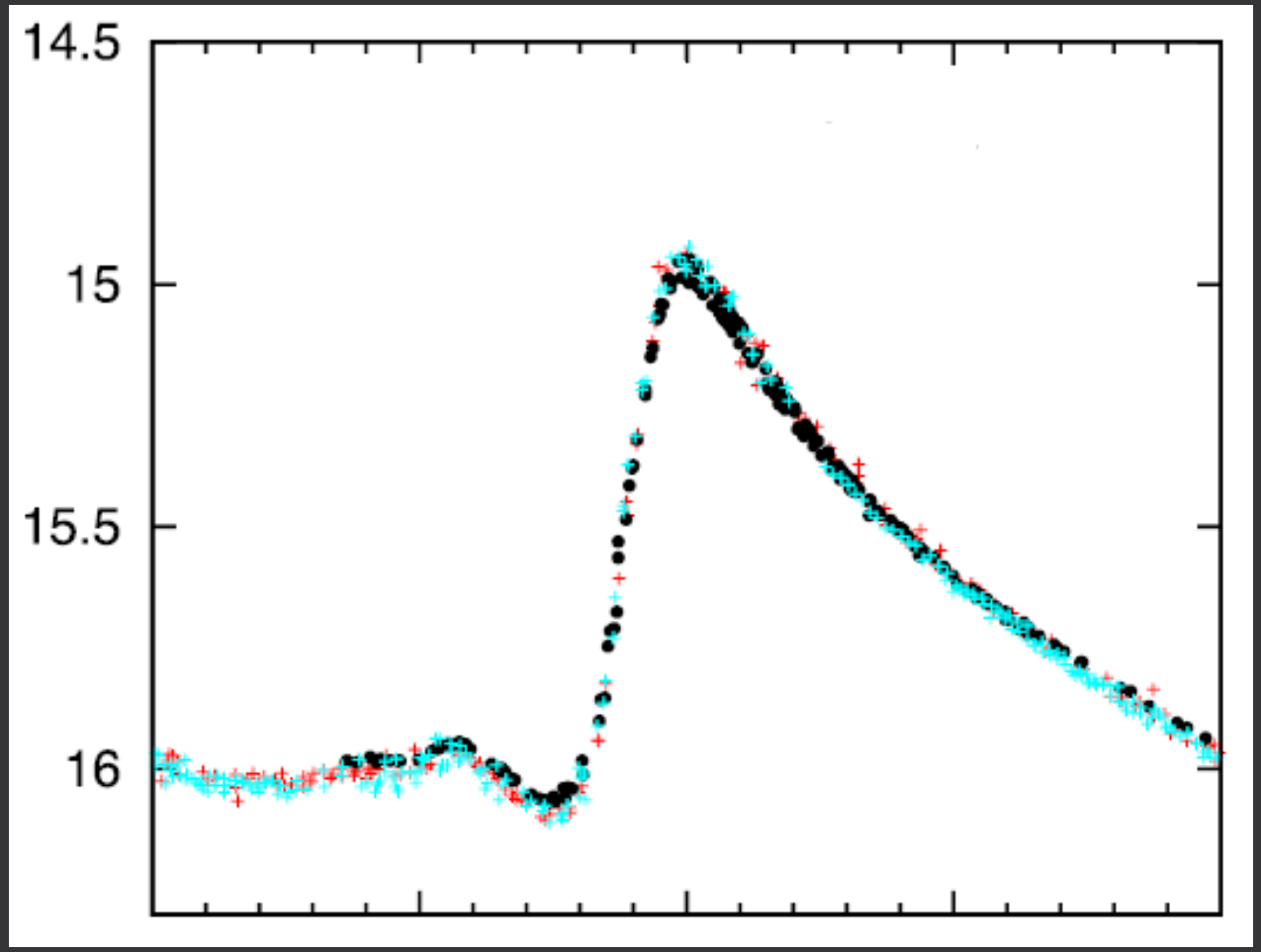
Distance de M3 selon Wikipedia: 33 920 a.l.


Starlight
B G R
J H K
500
560
650
1200
1500
2200
nm

Type de RR Lyre:

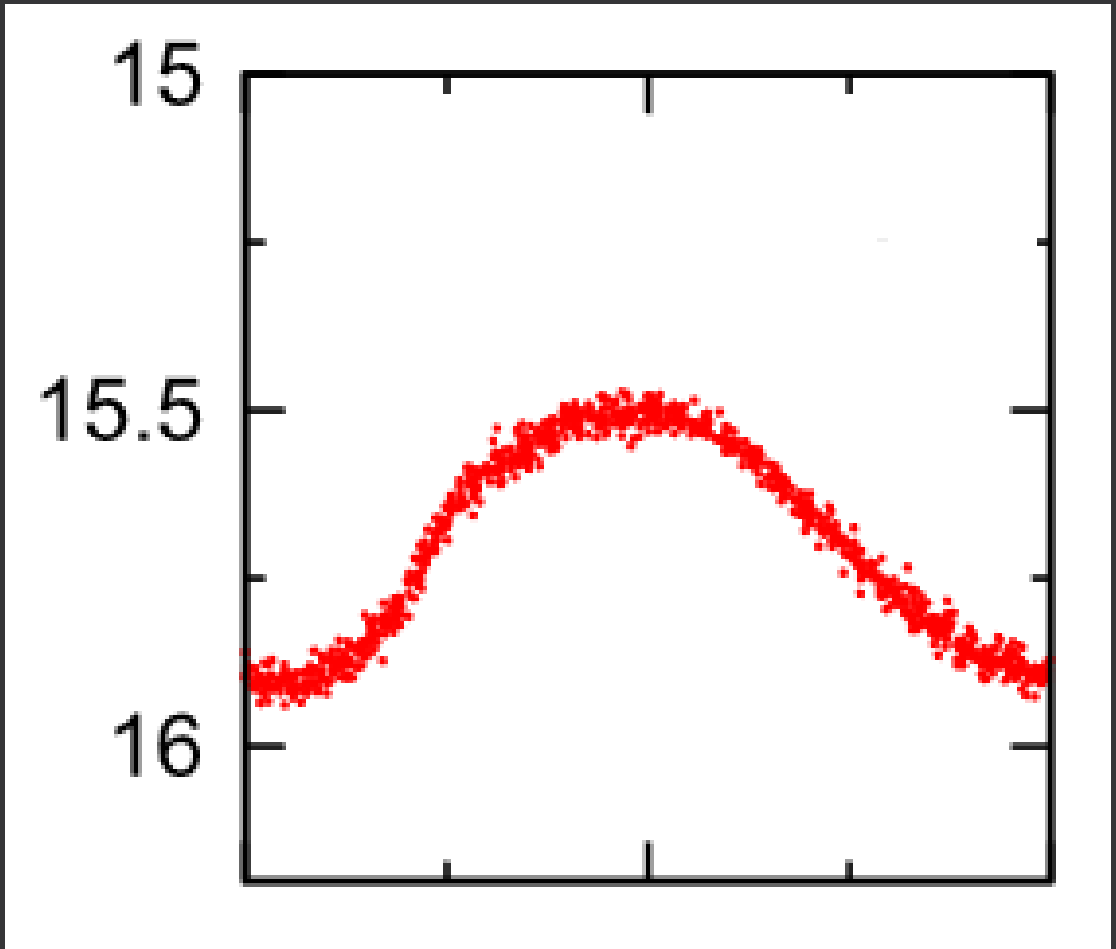
- ab
- c
- d

RR Lyrae - ab



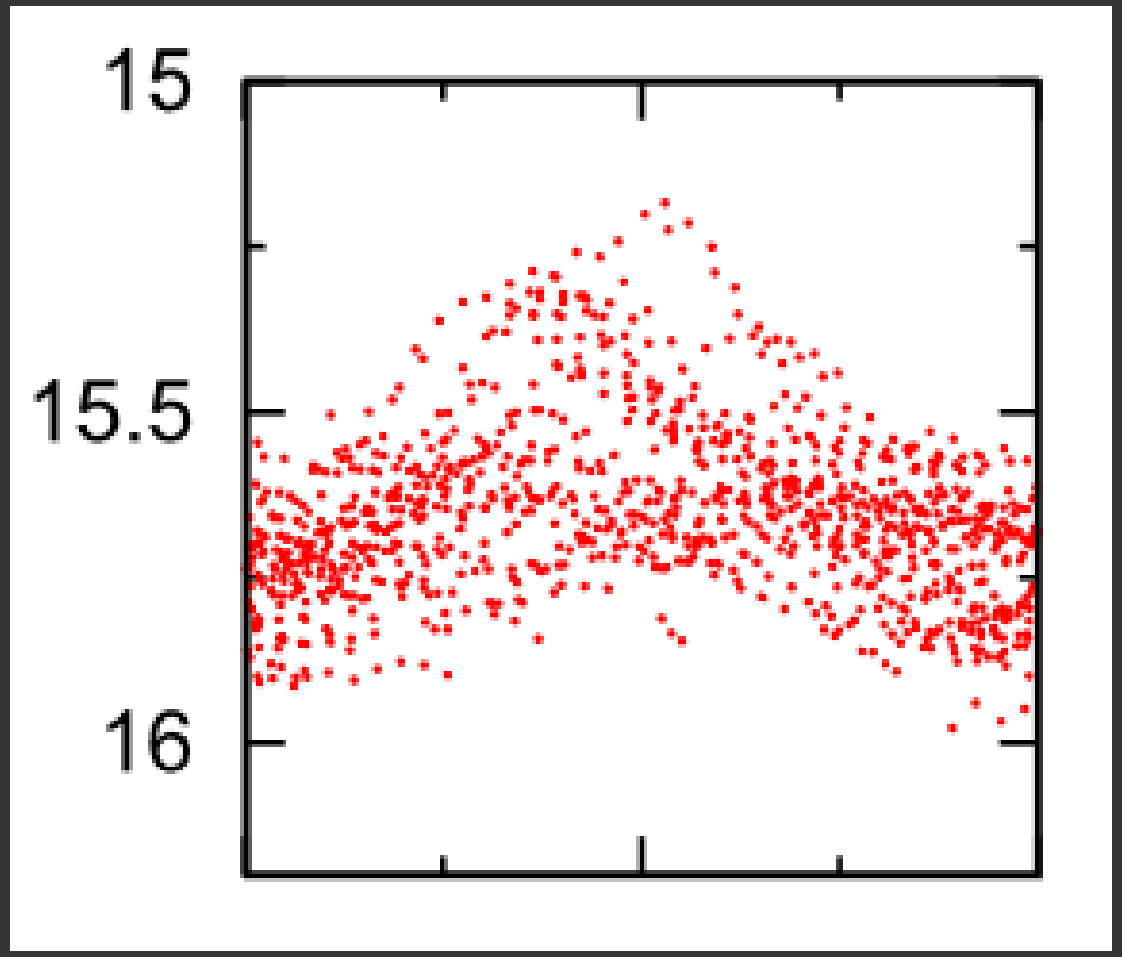
Référence: Jurcsik (2019)

RR Lyrae - c



Référence: Jurcsik (2019)

RR Lyrae - d

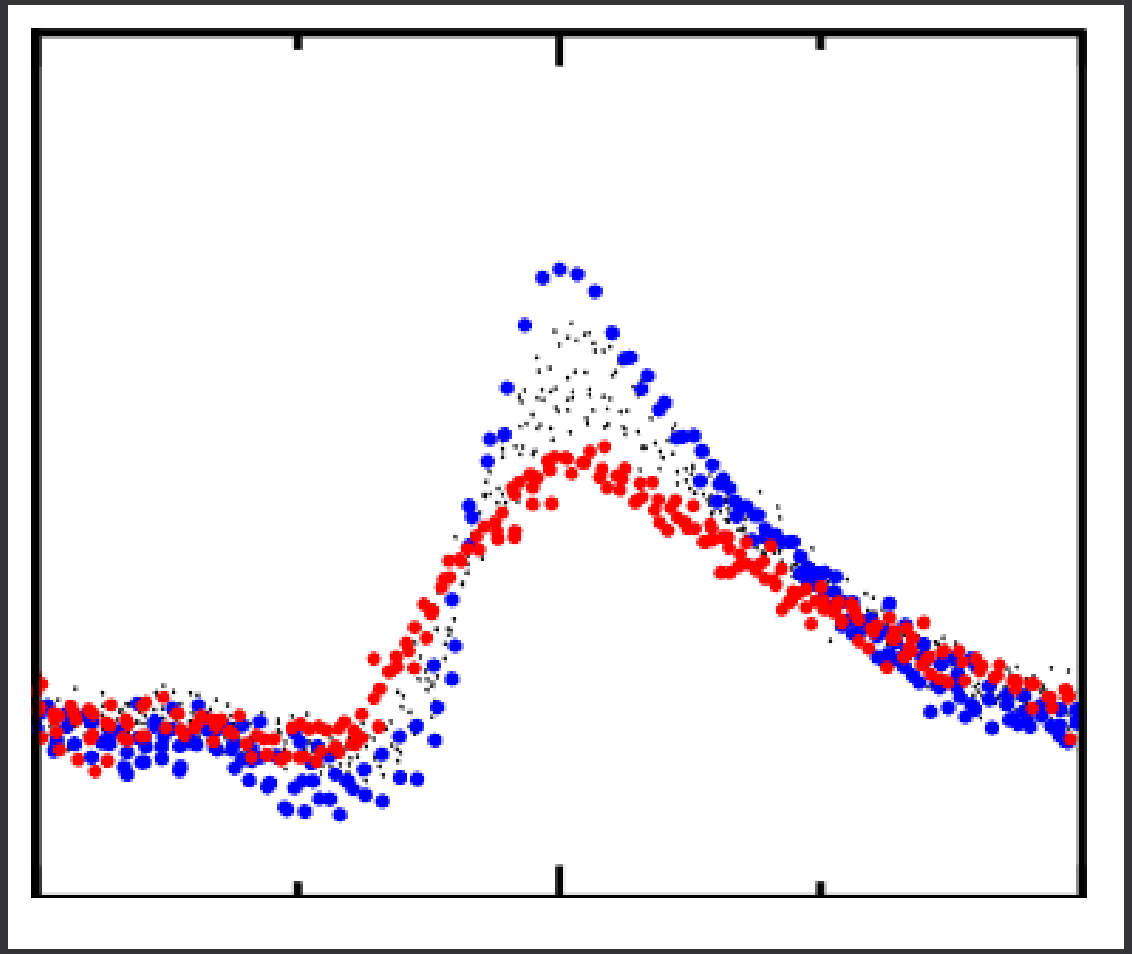


Référence: Jurcsik (2019)

Effet Blazhko

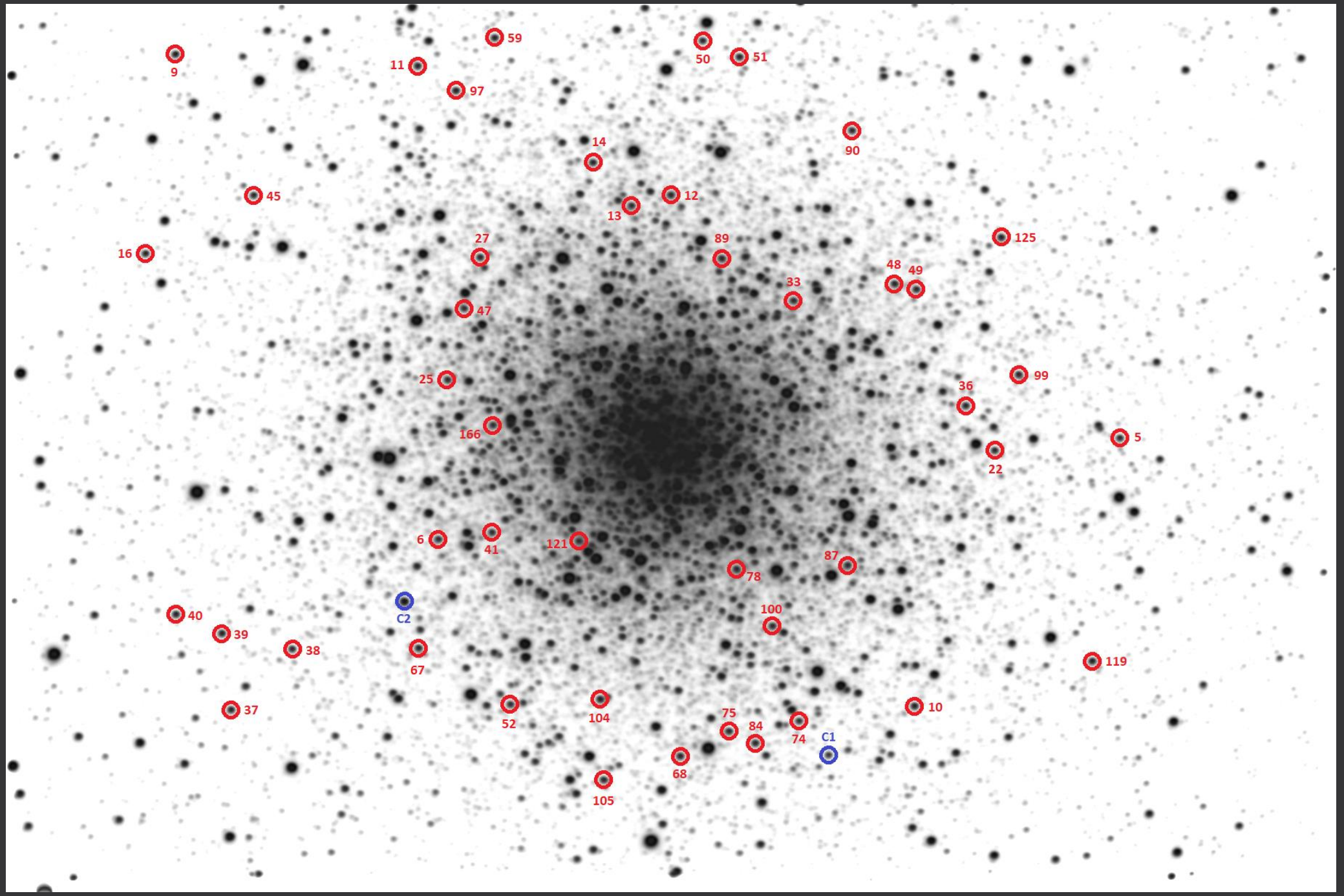
Variation dans l’amplitude et la période.
Découvert en 1907 par Sergey Blazhko (RW Draconis)
Raison toujours inconnue

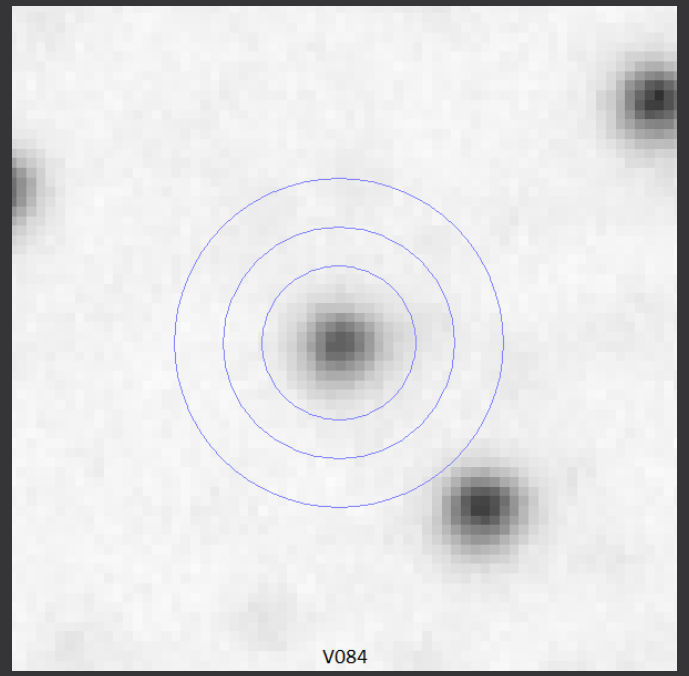
Effet Blazhko

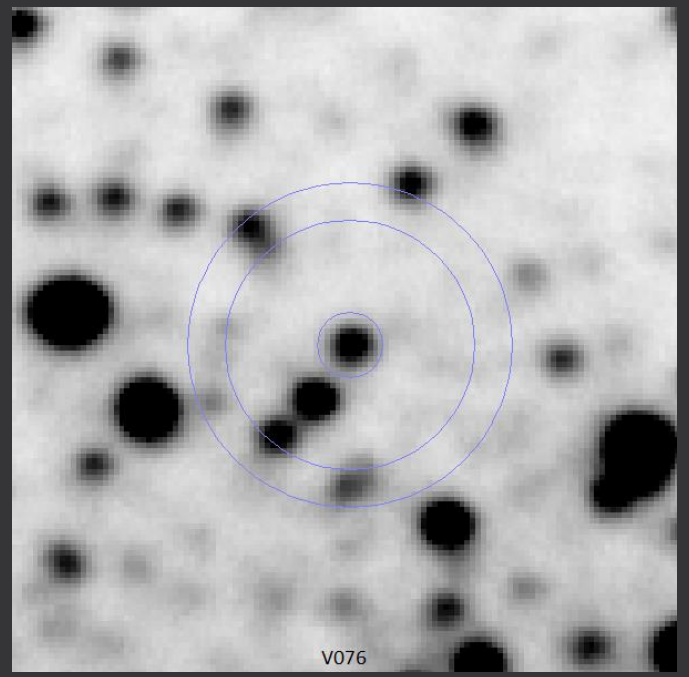


Référence: Jurcsik (2019)

Étude des étoiles variables de type RR Lyre dans l'amas globulaire Messier 3.


9
59
11
97
50
51
90
14
45
12
13
16
27
89
125
48
49
33
47
25
99
36
166
5
22
6
41
121
87
78
C2
40
39
38
100
67
119
37
52
104
10
75
84
74
C1
68
105


V084


V076

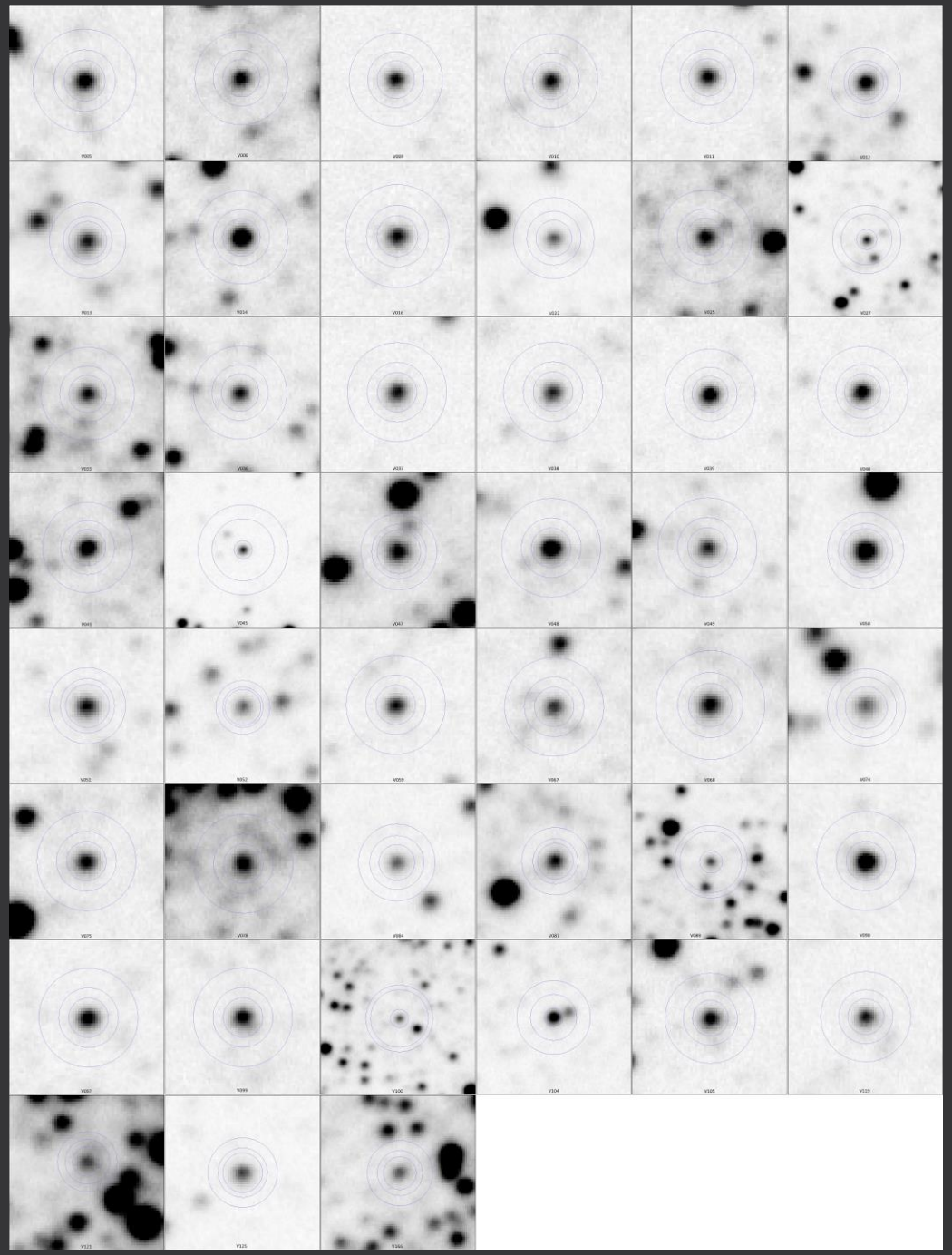


Table 1. Observations.

Date JD - 2460000	No. of Obs.
356.61754 – 356.68155	83
361.69303 – 361.78988	129
373.62040 – 373.79277	200
377.61851 – 377.78684	184
378.61789 – 378.77085	141
394.56883 – 394.70841	150
402.60789 – 402.72921	135
408.57742 – 408.68879	148
410.54815 – 410.69907	201
416.56395 – 416.67857	146
418.58564 – 418.68497	134
426.63970 – 426.75788	143
427.57423 – 427.70086	155
430.58531 – 430.73770	173
437.66314 – 437.73832	55
446.69147 – 446.78716	120
447.60757 – 447.72355	157
457.61617 – 457.71363	122
462.62717 – 462.75757	162
473.62641 – 473.68414	69
482.62855 – 482.67162	58

21 soirées d’observations

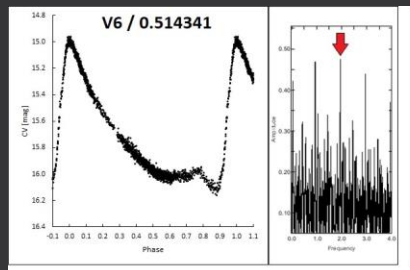
15 février 2024 – 20 juin 2024

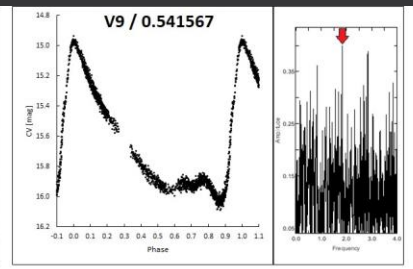
47 h 45 m

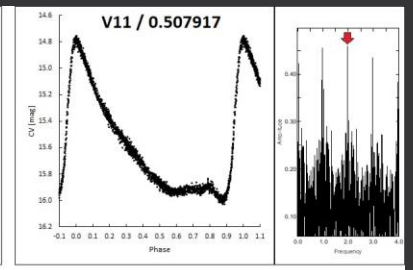
RRab / non-Blazhko

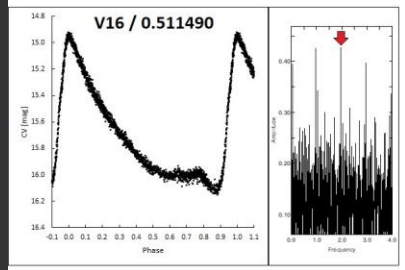
Table 2. RRab non-Blazhko stars.

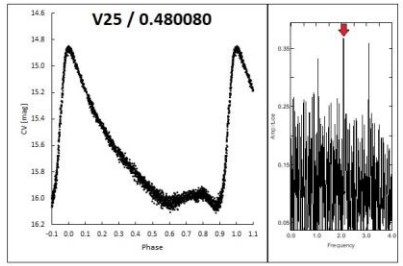
ID	Period (days)	Epoch (JD-2460000)	Mag. Range (CV)	Amplitude
V6	0.514341	500.385532	14.999 – 16.120	1.121
V9	0.541567	500.111139	14.978 – 16.036	1.058
V11	0.507917	500.279217	14.786 – 16.009	1.223
V16	0.511490	500.499393	14.870 – 16.082	1.212
V25	0.480080	500.216005	14.866 – 16.076	1.210
V27	0.579042	500.157119	15.140 – 16.080	0.940
V36	0.545649	500.059266	14.961 – 16.093	1.132
V40	0.551554	500.507970	15.073 – 16.075	1.002
V51	0.583980	500.348999	15.175 – 16.073	0.898
V74	0.492175	500.380947	14.932 – 16.178	1.246
V84	0.595731	500.350749	15.266 – 15.999	0.733
V89	0.548500	500.226750	15.053 – NA	NA
V90	0.517032	500.175455	14.954 – 16.105	1.151
V100	0.618813	500.163533	15.385 – 16.028	0.643

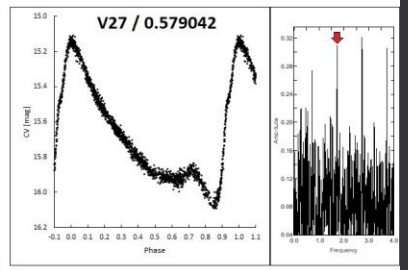

V6 / 0.514341
CV [mag]
Phase
Amp.Scat
Frequency

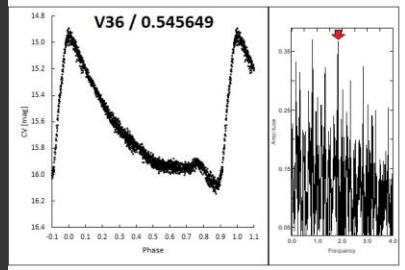

V9 / 0.541567
CV [mag]
Phase
Amp.Scat
Frequency

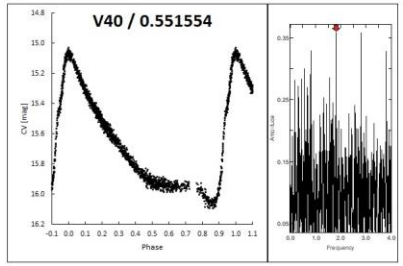

V11 / 0.507917
CV [mag]
Phase
Amp.Scat
Frequency

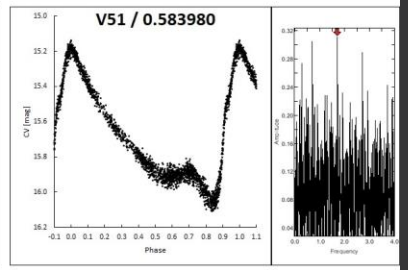

V16 / 0.511490
CV [mag]
Phase
Amp.Scat
Frequency

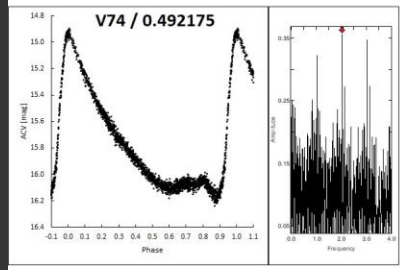

V25 / 0.480080
CV [mag]
Phase
Amp.Scat
Frequency

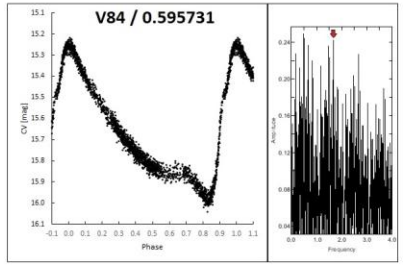

V27 / 0.579042
CV [mag]
Phase
Amp.Scat
Frequency

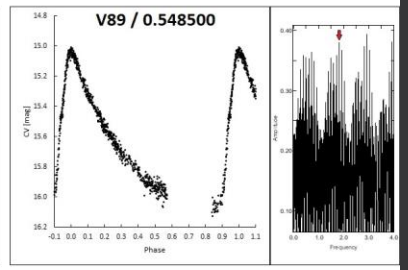

V36 / 0.545649
CV [mag]
Phase
Amp.Scat
Frequency

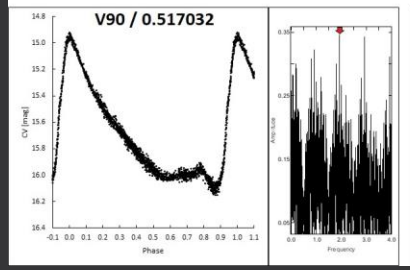

V40 / 0.551554
CV [mag]
Phase
Amp.Scat
Frequency

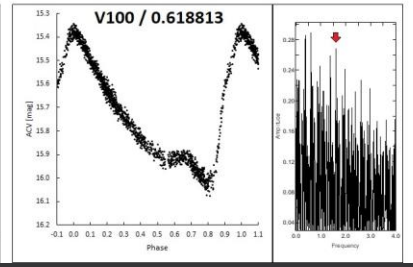

V51 / 0.583980
CV [mag]
Phase
Amp.Scat
Frequency

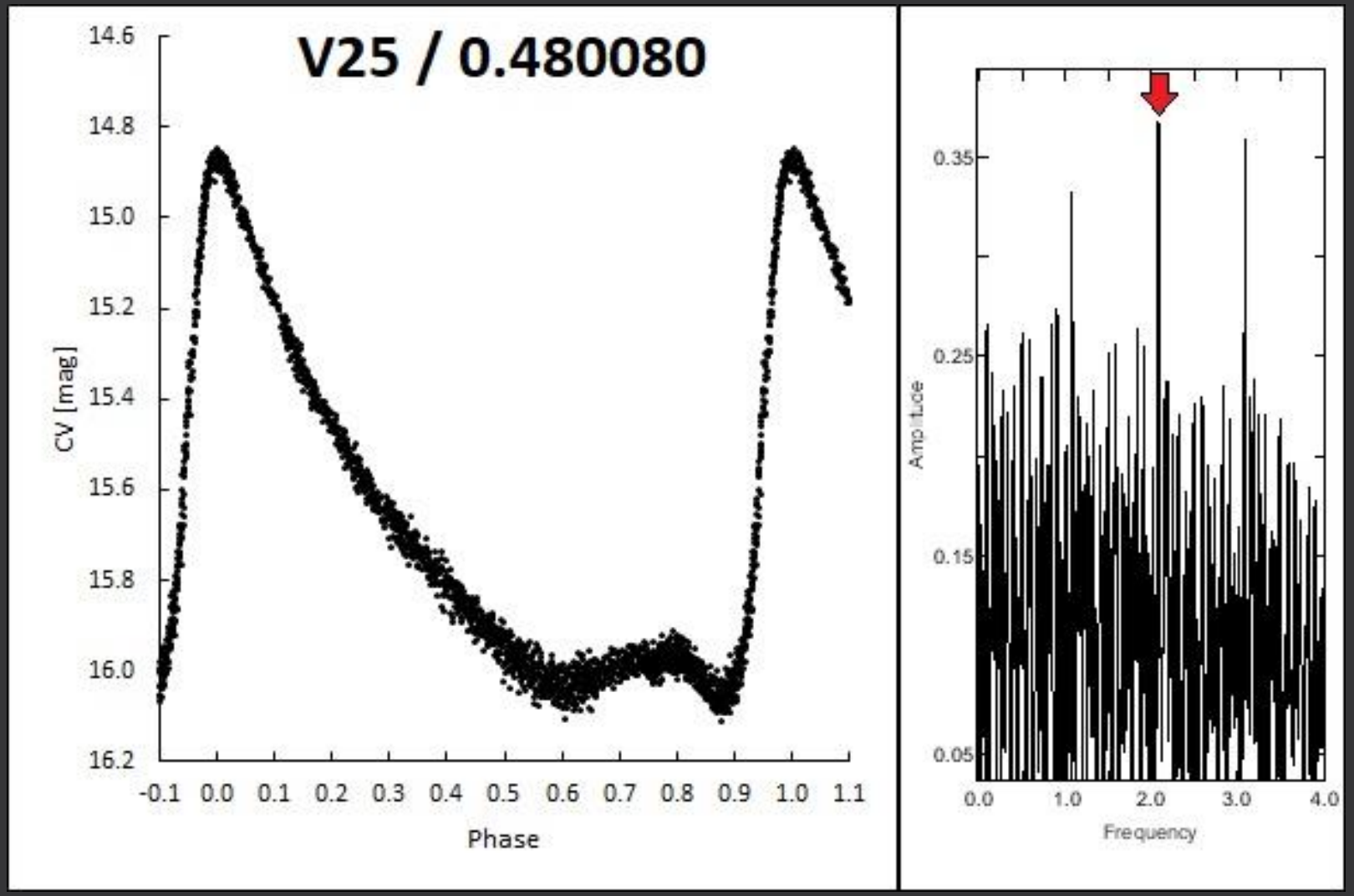

V74 / 0.492175
ACV [mag]
Phase
Amp.Scat
Frequency


V84 / 0.595731
CV [mag]
Phase
Amp.Scat
Frequency


V89 / 0.548500
CV [mag]
Phase
Amp.Scat
Frequency


V90 / 0.517032
CV [mag]
Phase
Amp.Scat
Frequency

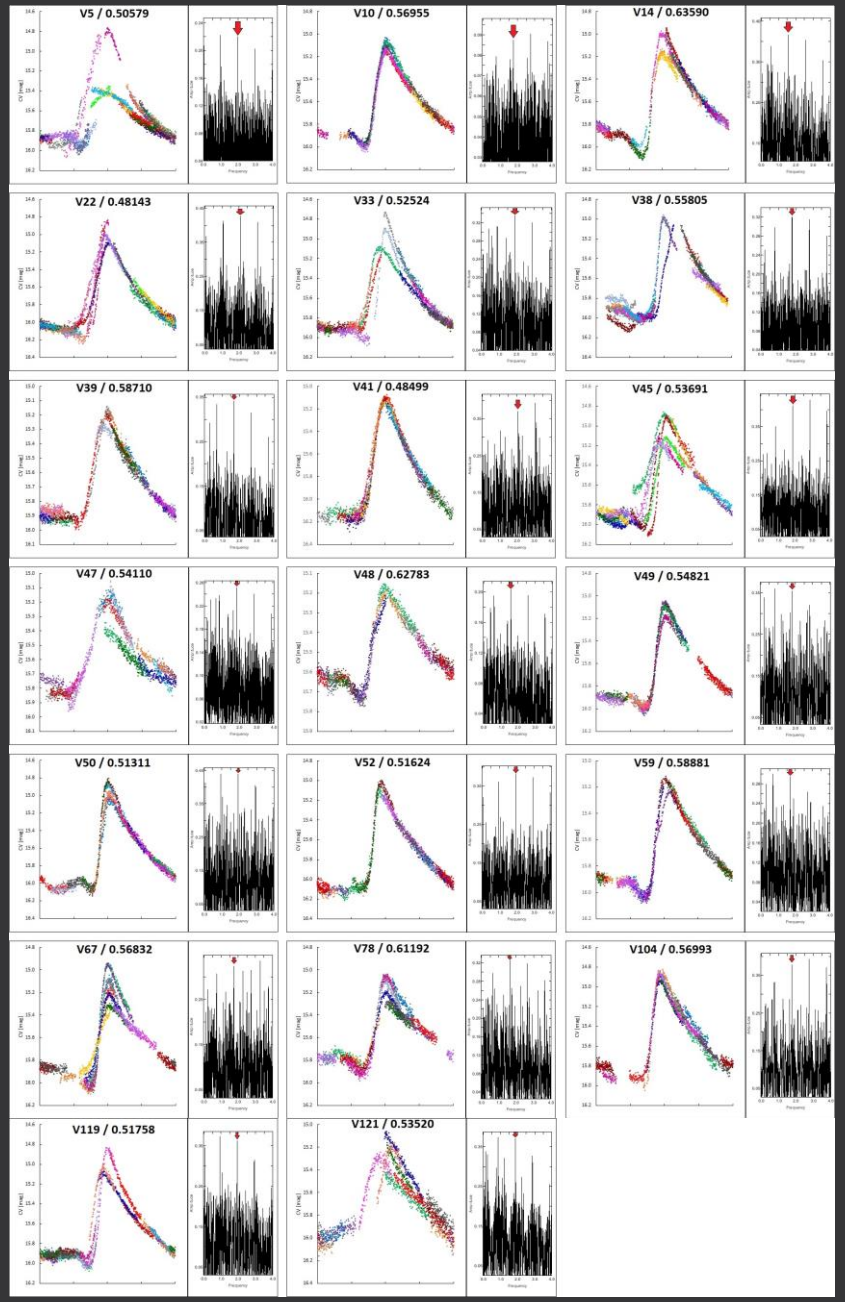

V100 / 0.618813
ACV [mag]
Phase
Amp.Scat
Frequency


V25 / 0.480080
CV [mag]
14.6
14.8
15.0
15.2
15.4
15.6
15.8
16.0
16.2
-0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1
Phase
Amplitude
0.35
0.25
0.15
0.05
0.0 1.0 2.0 3.0 4.0
Frequency

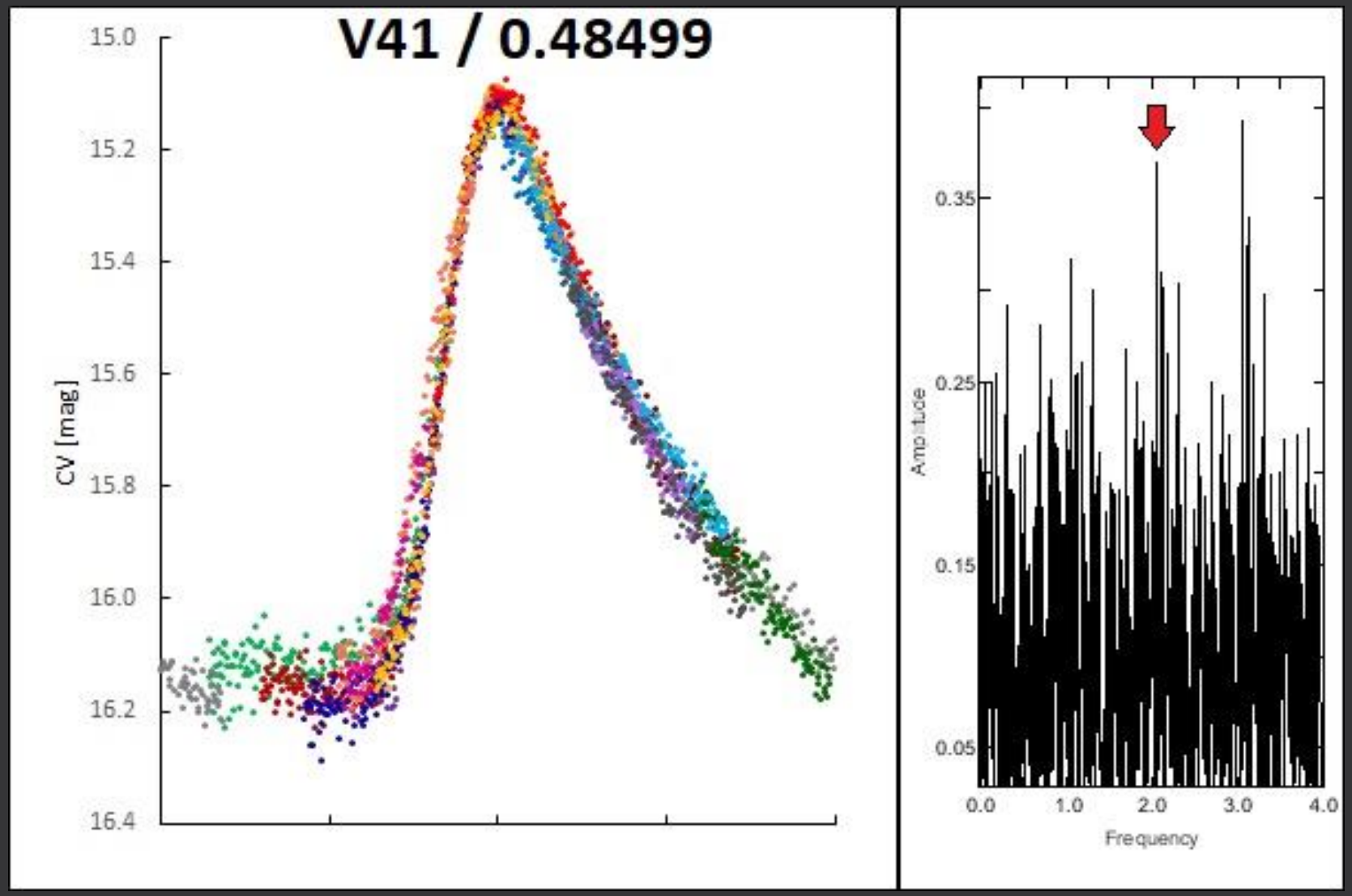
RRab / Effet Blazhko

Table 5. RRab Blazhko stars.

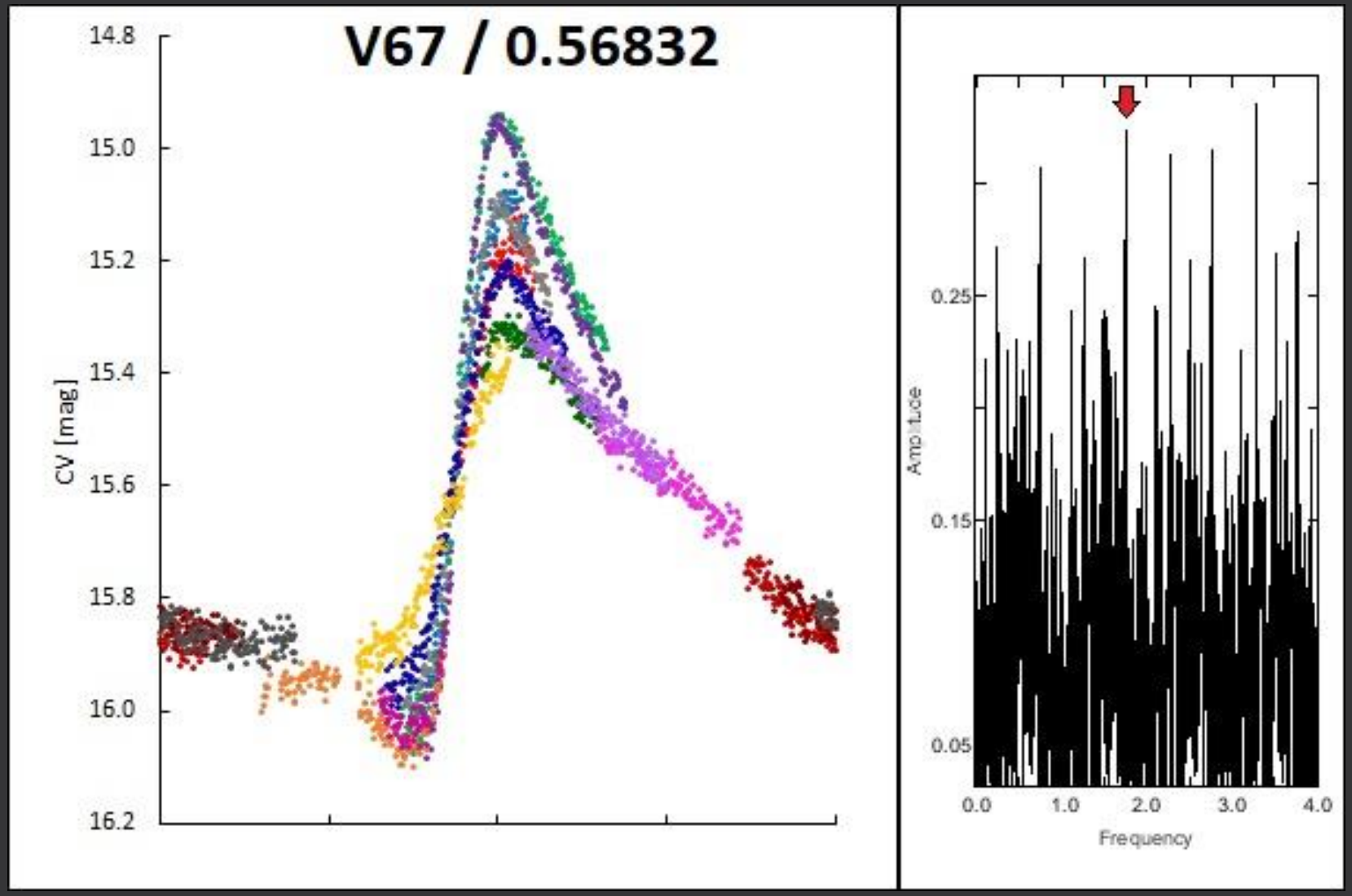
ID	Period (days)	Epoch (JD-2460000)	Ref
V5	0.50579	500.443490	J
V10	0.56955	500.124551	J
V14	0.63590	500.129141	J
V22	0.48143	500.157496	J
V33	0.52524	500.306780	J
V38	0.55805	500.504141	A
V39	0.58710	500.168726	J
V41	0.48499	500.410076	P4
V45	0.53691	500.463249	J
V47	0.54110	500.260422	J
V48	0.62783	500.471267	J
V49	0.54821	500.519202	J
V50	0.51311	500.267314	A
V52	0.51624	500.261000	J
V59	0.58881	500.207686	A
V67	0.56832	500.440600	J
V78	0.61192	500.569663	J
V104	0.56993	500.086752	J
V119	0.51758	500.126300	J
V121	0.53520	500.468831	J


V5 / 0.50579
V10 / 0.56955
V14 / 0.63590
V22 / 0.48143
V33 / 0.52524
V38 / 0.55805
V39 / 0.58710
V41 / 0.48499
V45 / 0.53691
V47 / 0.54110
V48 / 0.62783
V49 / 0.54821
V50 / 0.51311
V52 / 0.51624
V59 / 0.58881
V67 / 0.56832
V78 / 0.61192
V104 / 0.56993
V119 / 0.51758
V121 / 0.53520

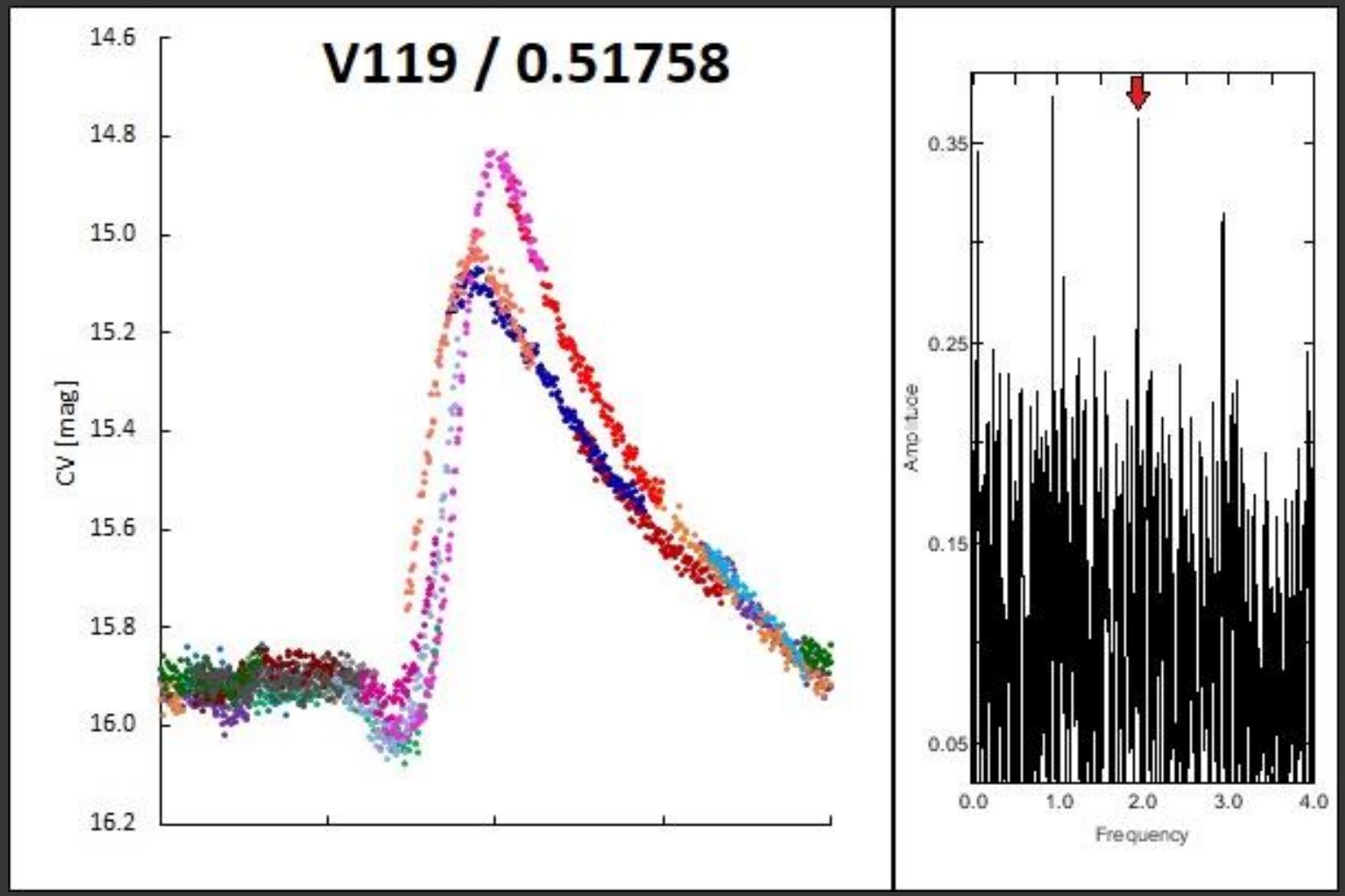
Modulation sur la période



Modulation sur l’amplitude



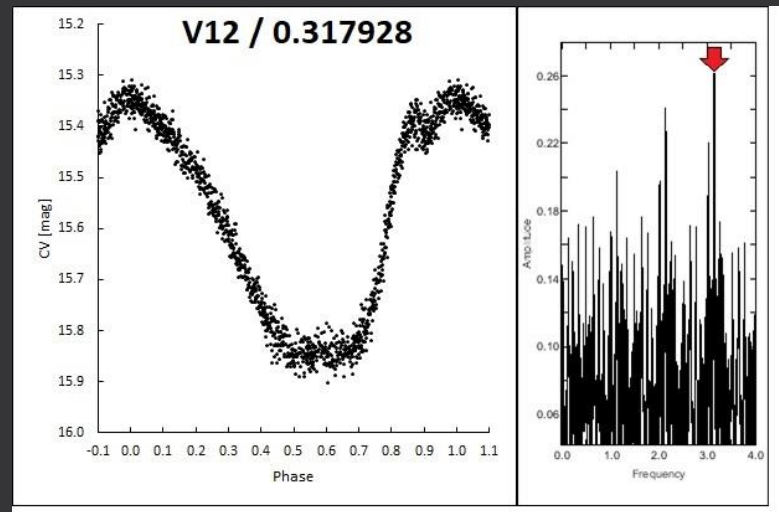
Modulation sur la période et l'amplitude



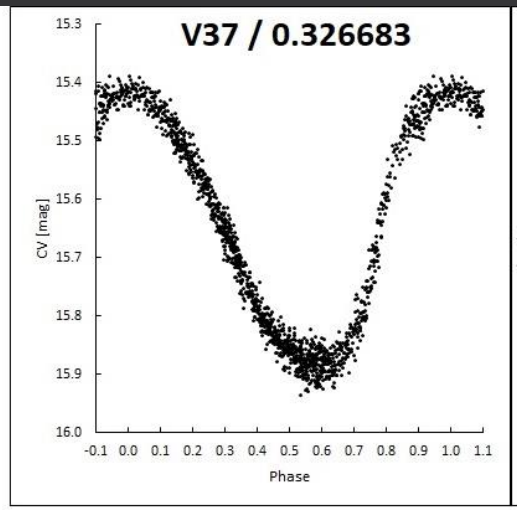
RRc

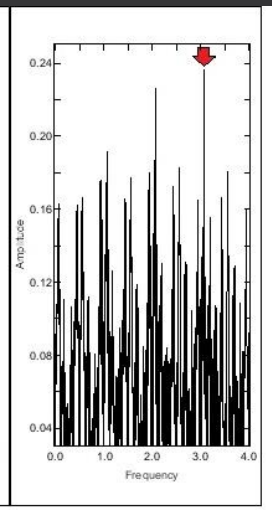
Table 3. RRc stars.

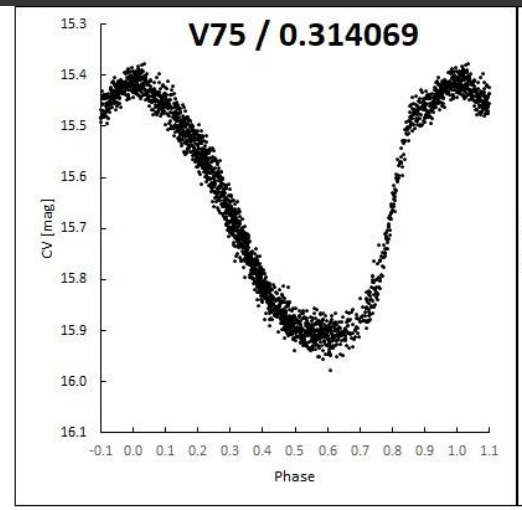
ID	Period (days)	Epoch (JD-2460000)	Mag. Range (CV)	Amplitude
V12	0.317928	500.211376	15.349 – 15.858	0.509
V37	0.326682	500.099549	15.410 – 15.894	0.484
V75	0.314069	500.017524	15.411 – 15.923	0.512
V97	0.334961	500.020035	15.486 – 15.948	0.462
V105	0.287744	500.227448	15.382 – 15.703	0.321
V125	0.349815	500.222287	15.444 – 15.866	0.422

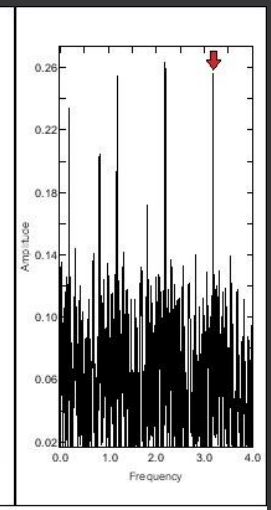

V12 / 0.317928
CV [mag]
Phase

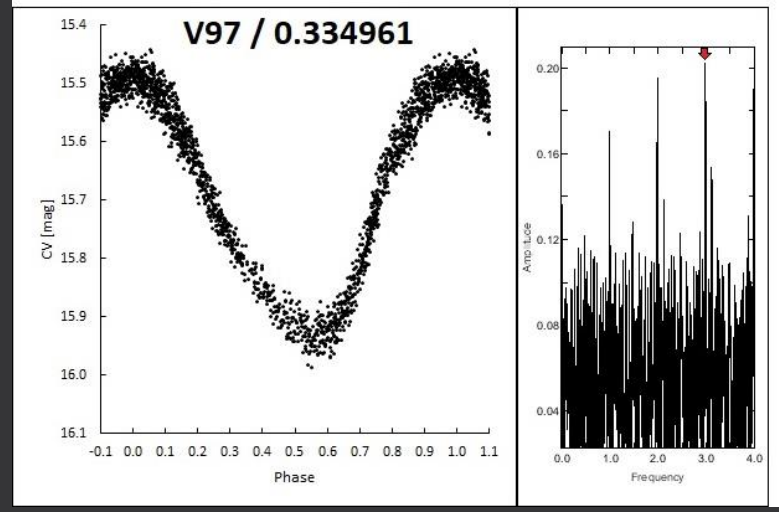
Amplitude
Frequency


V37 / 0.326683
CV [mag]
Phase

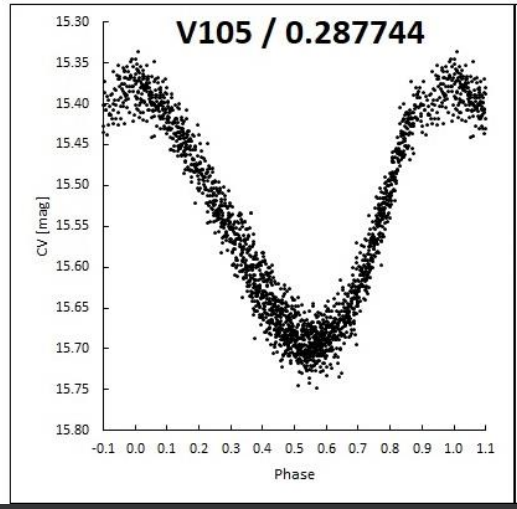

Amplitude
Frequency

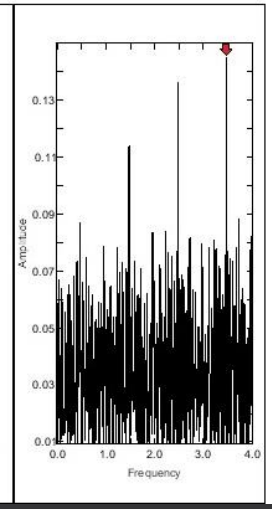

V75 / 0.314069
CV [mag]
Phase

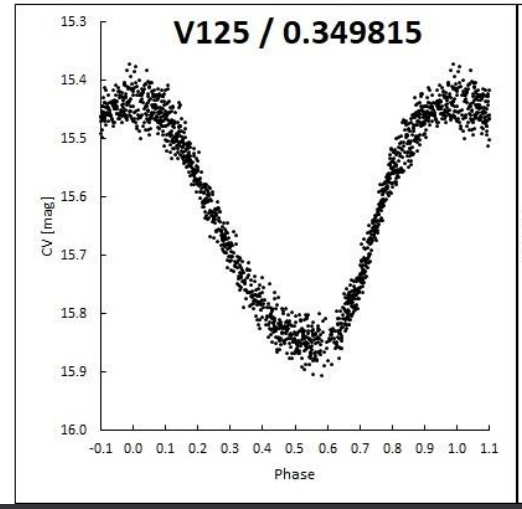

Amplitude
Frequency

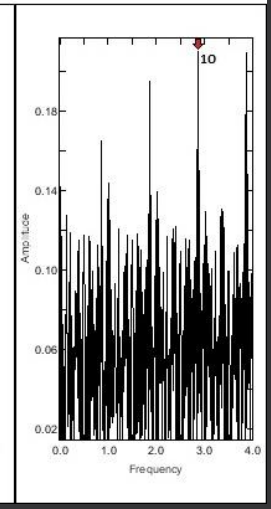

V97 / 0.334961
CV [mag]
Phase

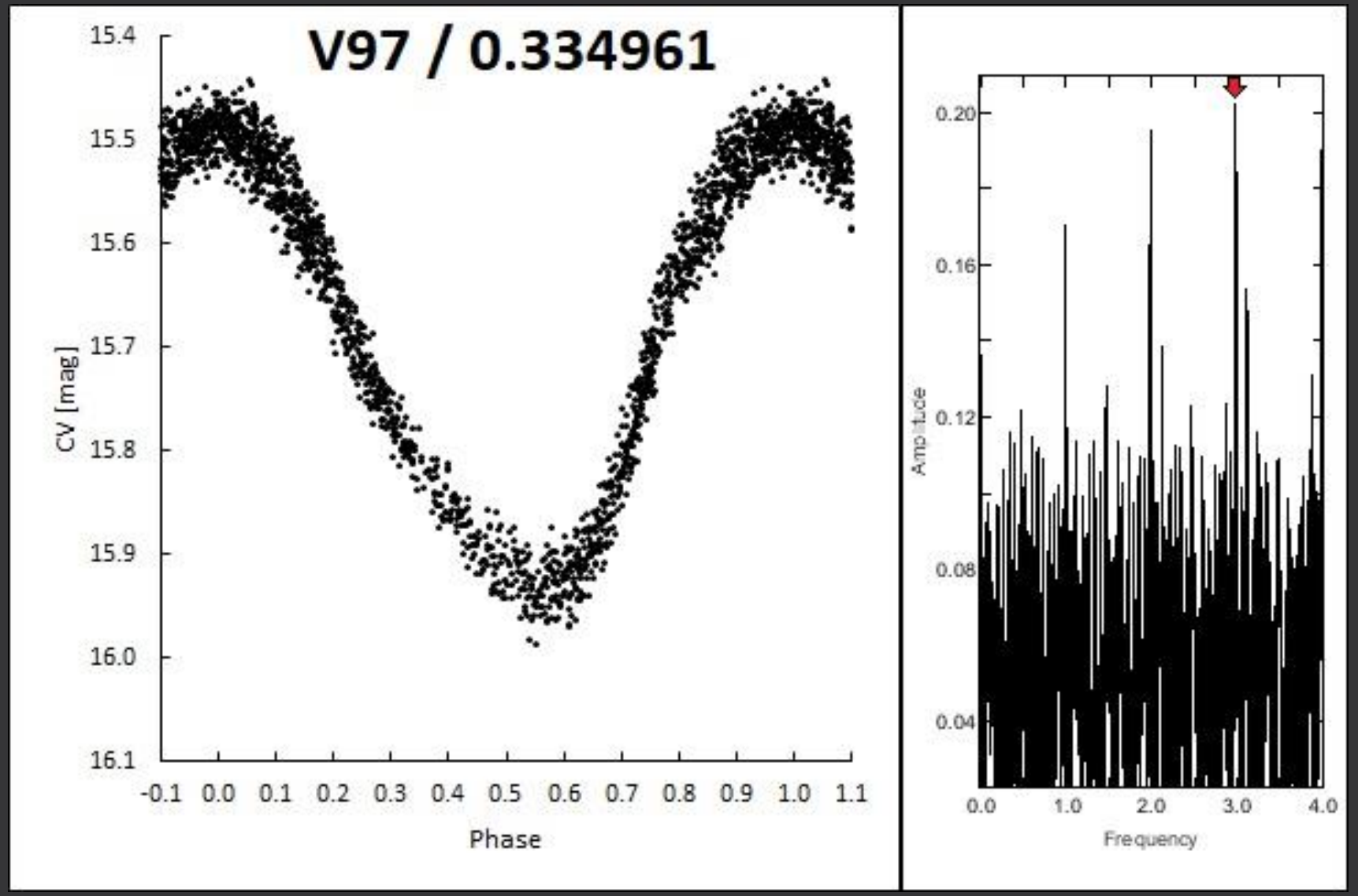
Amplitude
Frequency

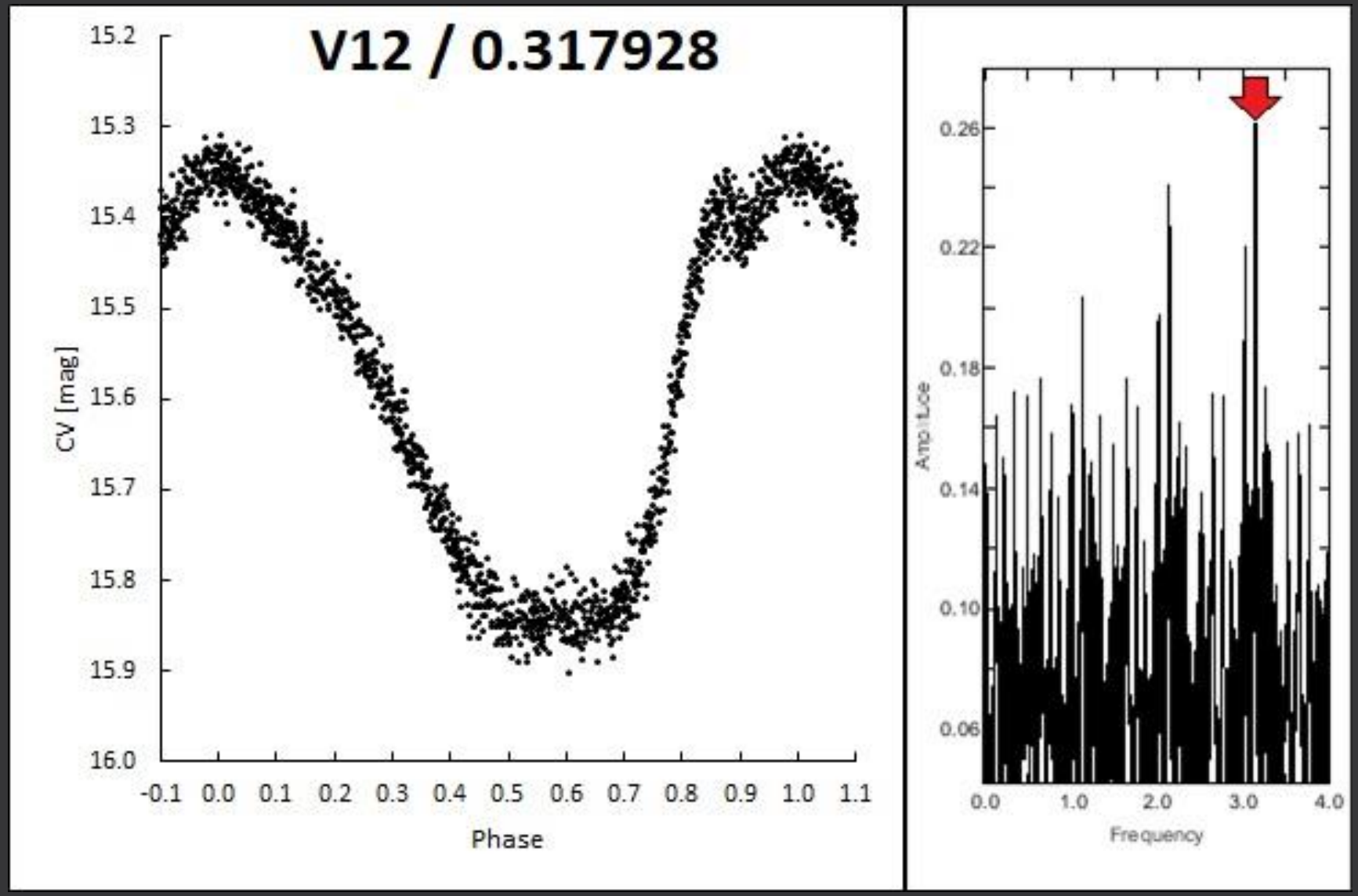

V105 / 0.287744
CV [mag]
Phase


Amplitude
Frequency


V125 / 0.349815
CV [mag]
Phase


10
Amplitude
Frequency

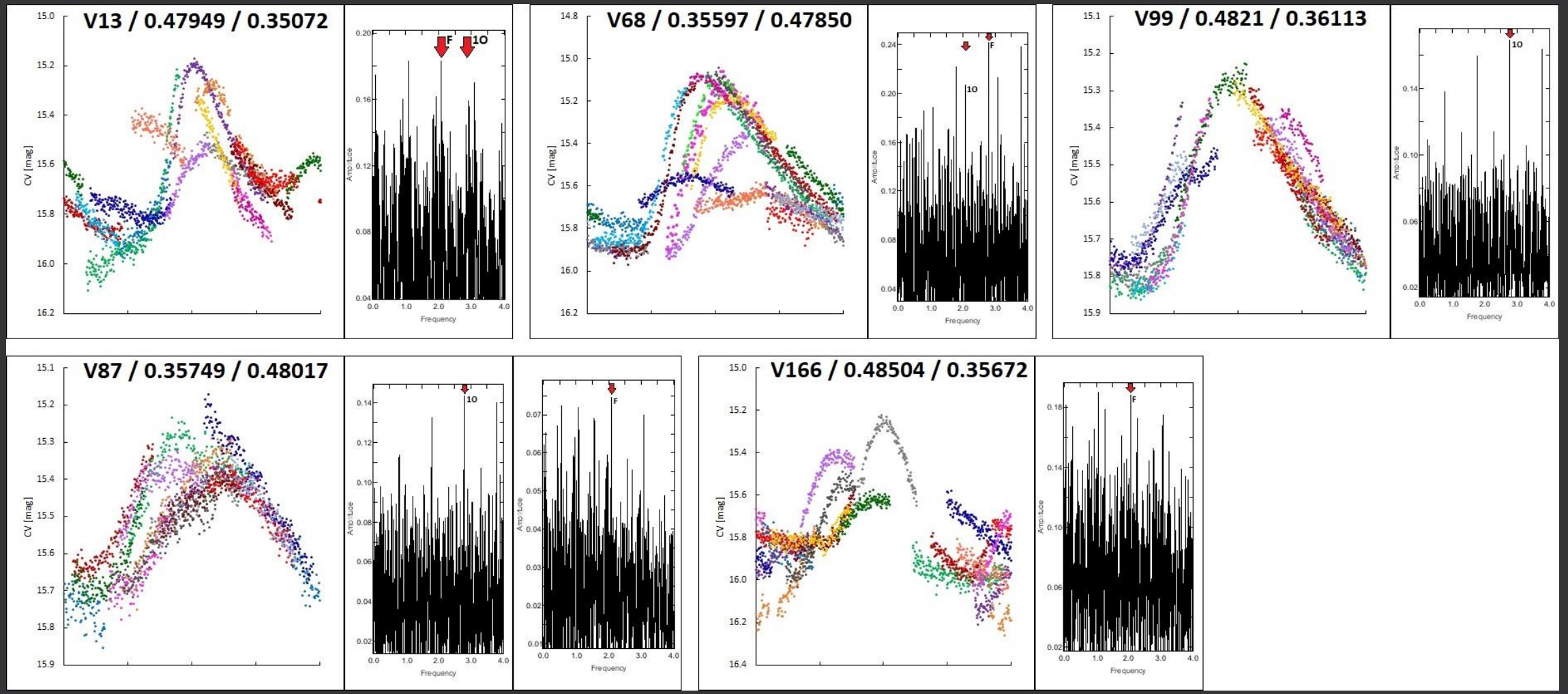

V97 / 0.334961
15.4
15.5
15.6
15.7
15.8
15.9
16.0
16.1
CV [mag]
-0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1
Phase
0.20
0.16
0.12
0.08
0.04
Amplitude
0.0 1.0 2.0 3.0 4.0
Frequency

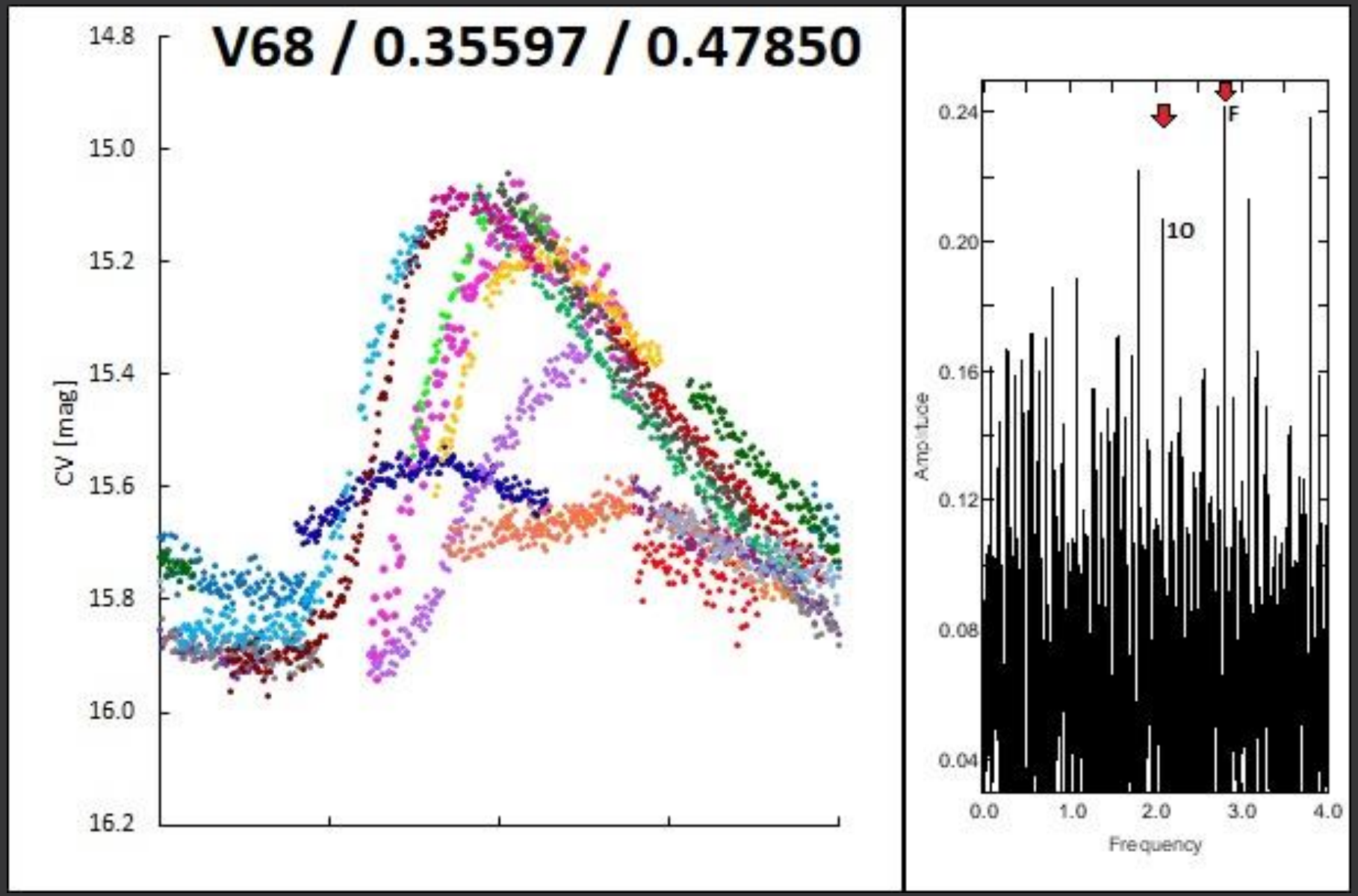

V12 / 0.317928
15.2
15.3
15.4
15.5
15.6
15.7
15.8
15.9
16.0
CV [mag]
-0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1
Phase
0.26
0.22
0.18
0.14
0.10
0.06
Amplitude
0.0 1.0 2.0 3.0 4.0
Frequency

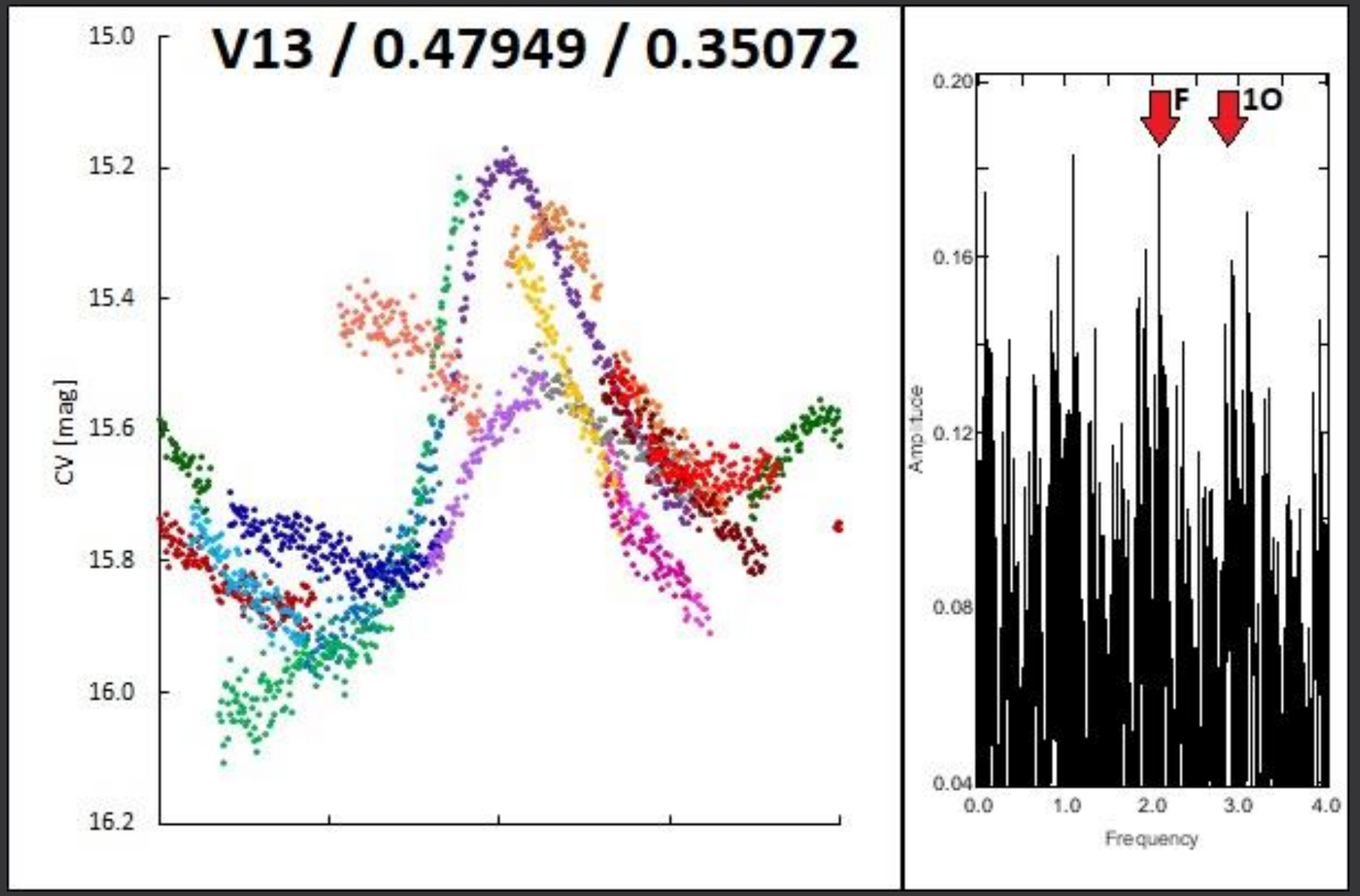
RRd

Table 6. RRd stars.

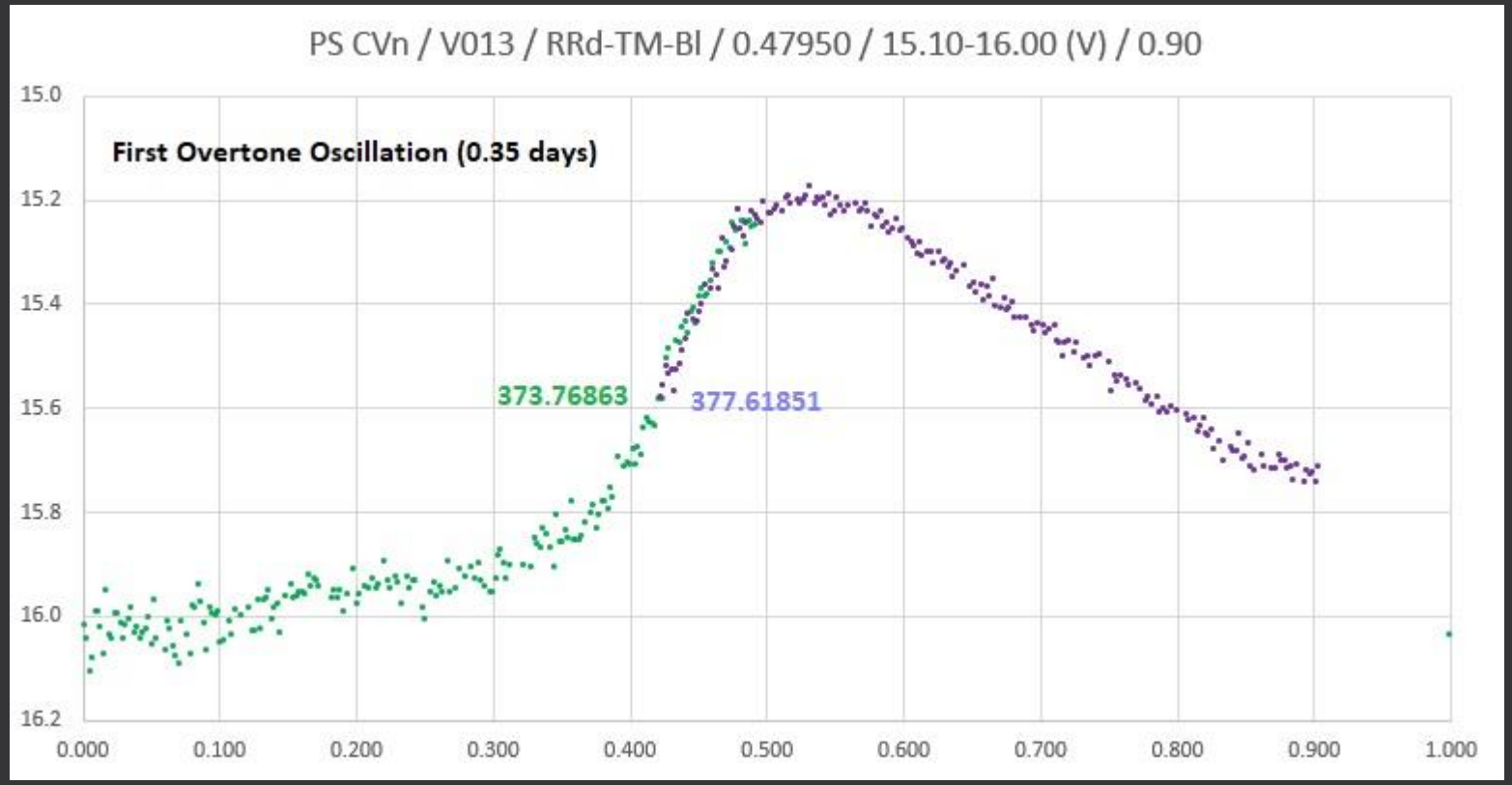
ID	Period (days)	Mode	Amplitude (mmag)
V13	0.47949	F	0.182
	0.35072	1O	0.126
	0.2816	2O	0
V68	0.47850	F	0.204
	0.35597	1O	0.214
V87	0.48017	F	0.083
	0.35749	1O	0.184
V99	0.4821	F	0
	0.36113	1O	0.168
V166	0.48504	F	0.190
	0.35672	1O	0


V13 / 0.47949 / 0.35072
F
1O
V68 / 0.35597 / 0.47850
F
1O
V99 / 0.4821 / 0.36113
1O
V87 / 0.35749 / 0.48017
1O
F
V166 / 0.48504 / 0.35672
F
CV [mag]
Amplitude
Frequency

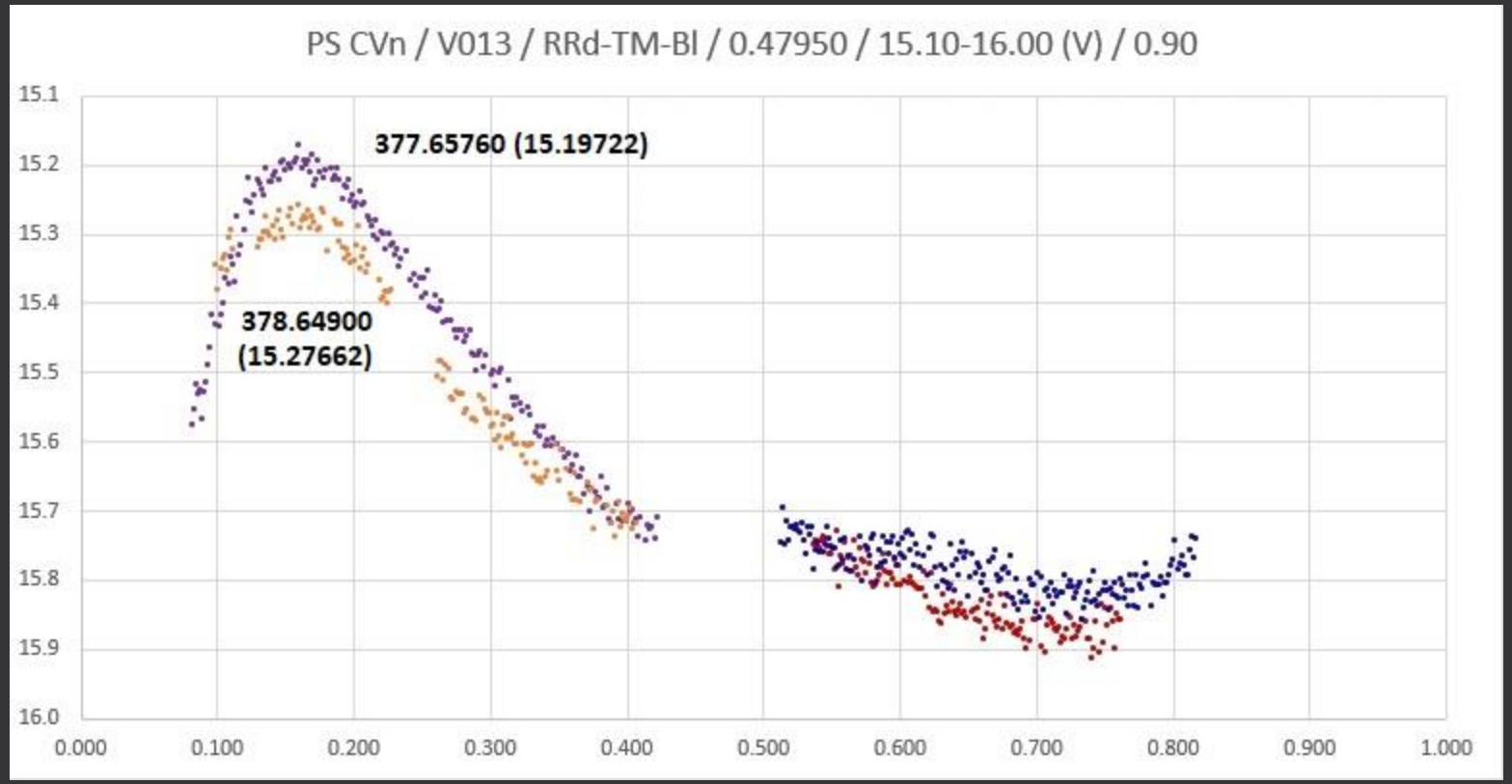

V68 / 0.35597 / 0.47850
14.8
15.0
15.2
15.4
15.6
15.8
16.0
16.2
CV [mag]
0.24
0.20
0.16
0.12
0.08
0.04
Amplitude
F
10
0.0
1.0
2.0
3.0
4.0
Frequency


V13 / 0.47949 / 0.35072
15.0
15.2
15.4
15.6
15.8
16.0
16.2
CV [mag]
F
1O
0.20
0.16
0.12
0.08
0.04
Amplitude
0.0
1.0
2.0
3.0
4.0
Frequency

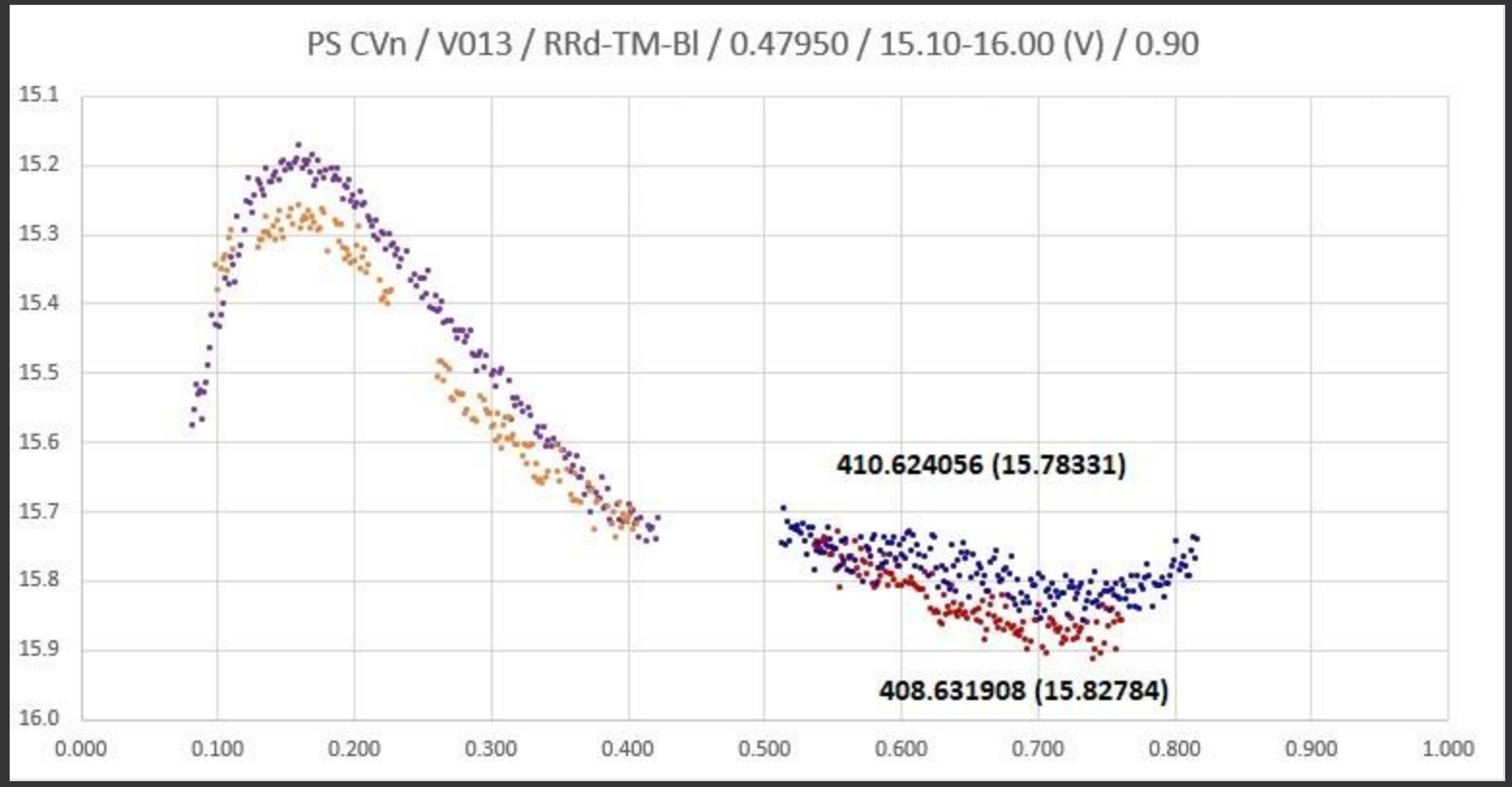
Première harmonique (373.76863-377.61851)



Mode fundamental (377.6576-378.649)



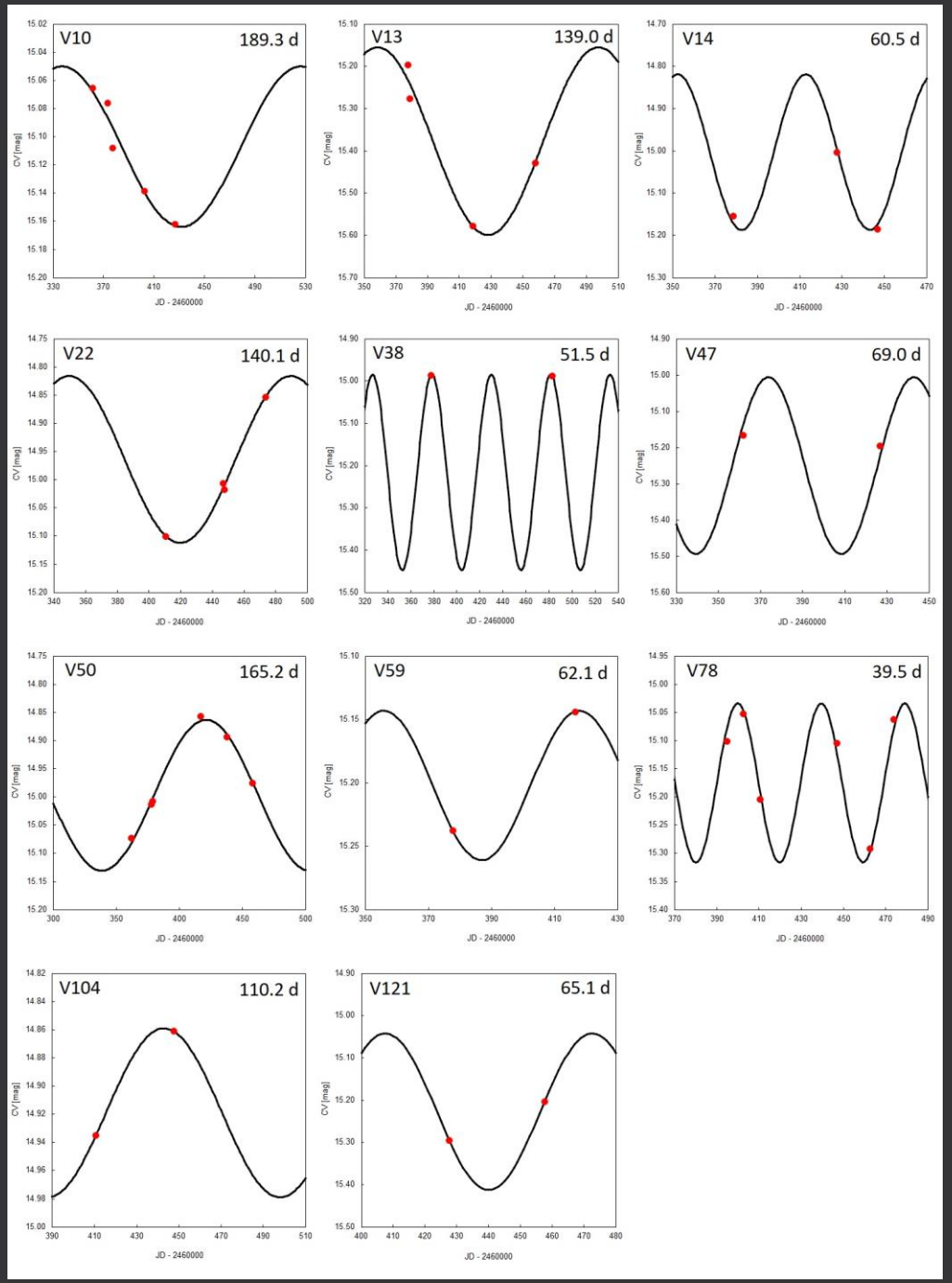
Mode fundamental (408.6319-410.6241)

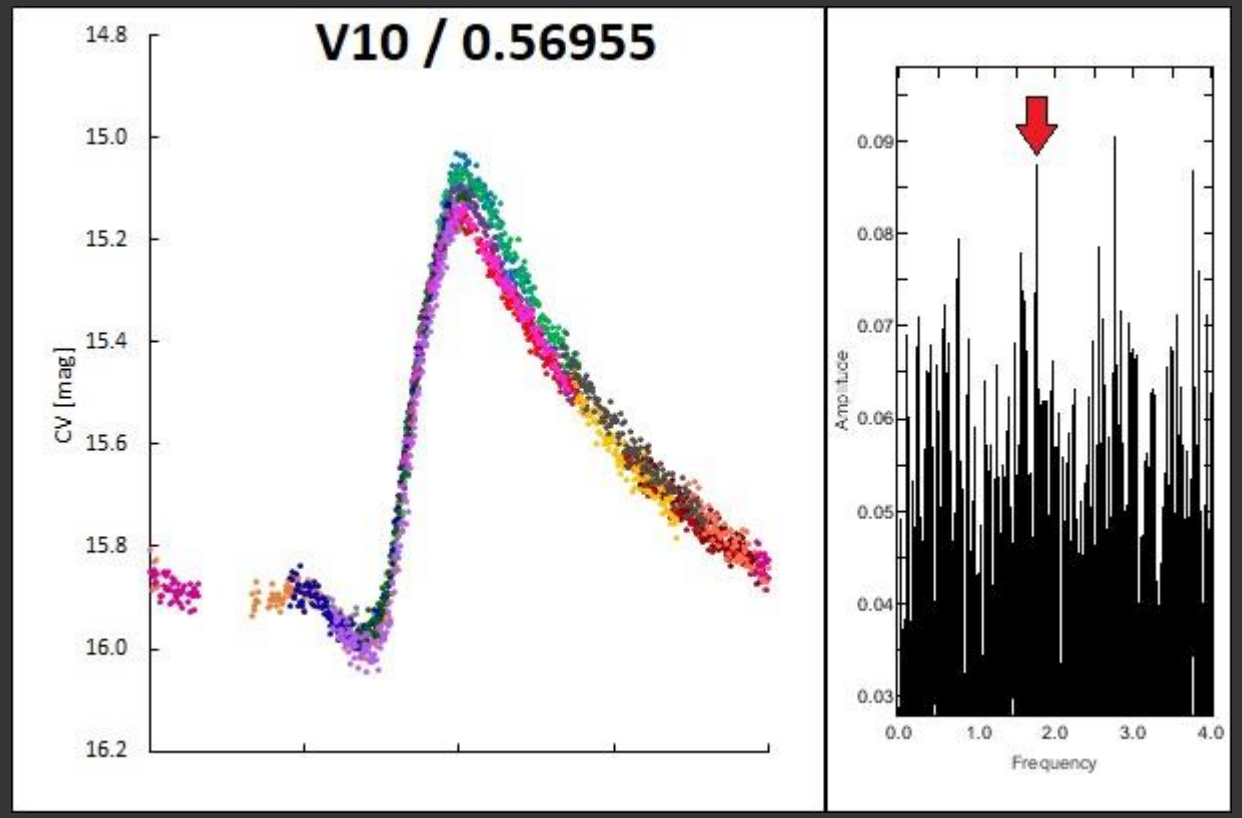


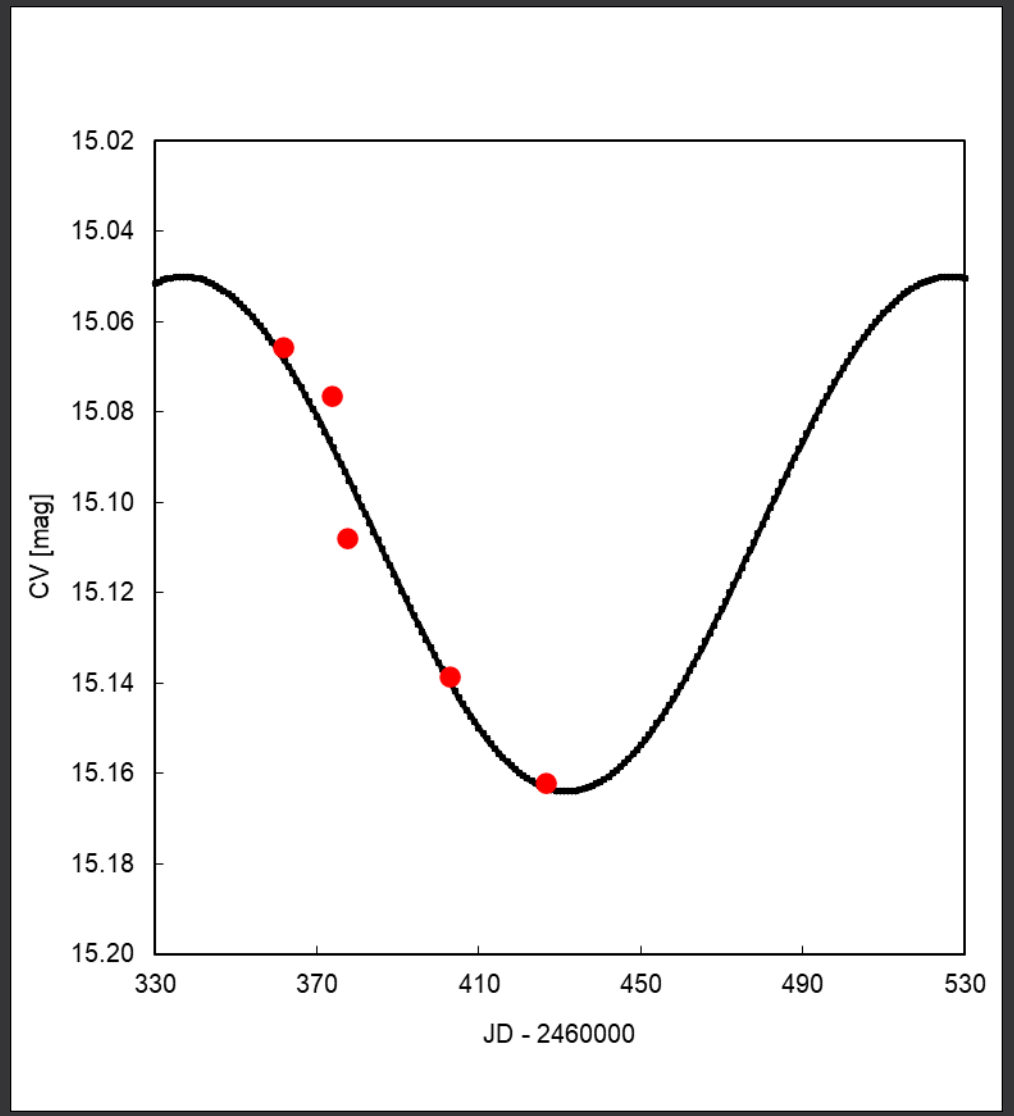
Effet Blazhko

Table 4. Blazhko periods and epochs from maximum magnitude

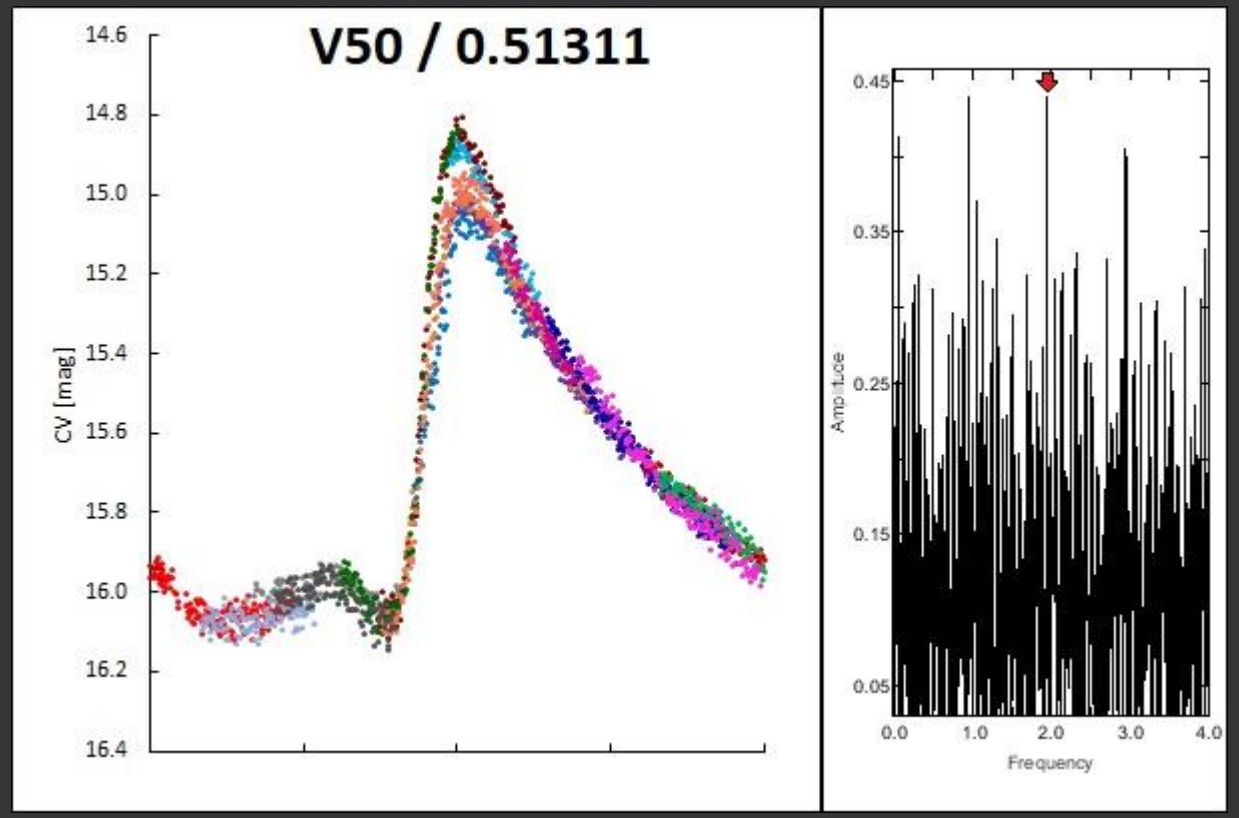
ID	Period (days)	Epoch (JD-2460000)	Mag. Range (CV)	Amplitude
V10	189.273903	336.95850	15.050 – 15.164	0.114
V13	138.959726	358.52330	15.155 – 15.599	0.444
V14	60.476026	352.33360	14.856 – 15.187	0.331
V22	140.146824	349.51910	14.816 – 15.112	0.296
V33	40.469648	356.13270	NA	0.465
V38	51.638965	373.89580	14.952 – 15.386	0.434
V45	26.695320	377.45025	NA	0.402
V47	68.990505	373.72485	15.006 – 15.493	0.487
V50	165.259190	420.01230	14.856 – 15.149	0.293
V59	62.117747	417.91255	15.143 – 15.261	0.118
V67	102.984975	381.62980	14.947 – 15.407	0.460
V78	39.544549	478.98785	15.035 – 15.316	0.281
V104	110.151575	442.90970	14.859 – 14.979	0.120
V121	65.1272	472.56180	15.042 – 15.412	0.370
V166	43.203732	448.06940	NA	0.451

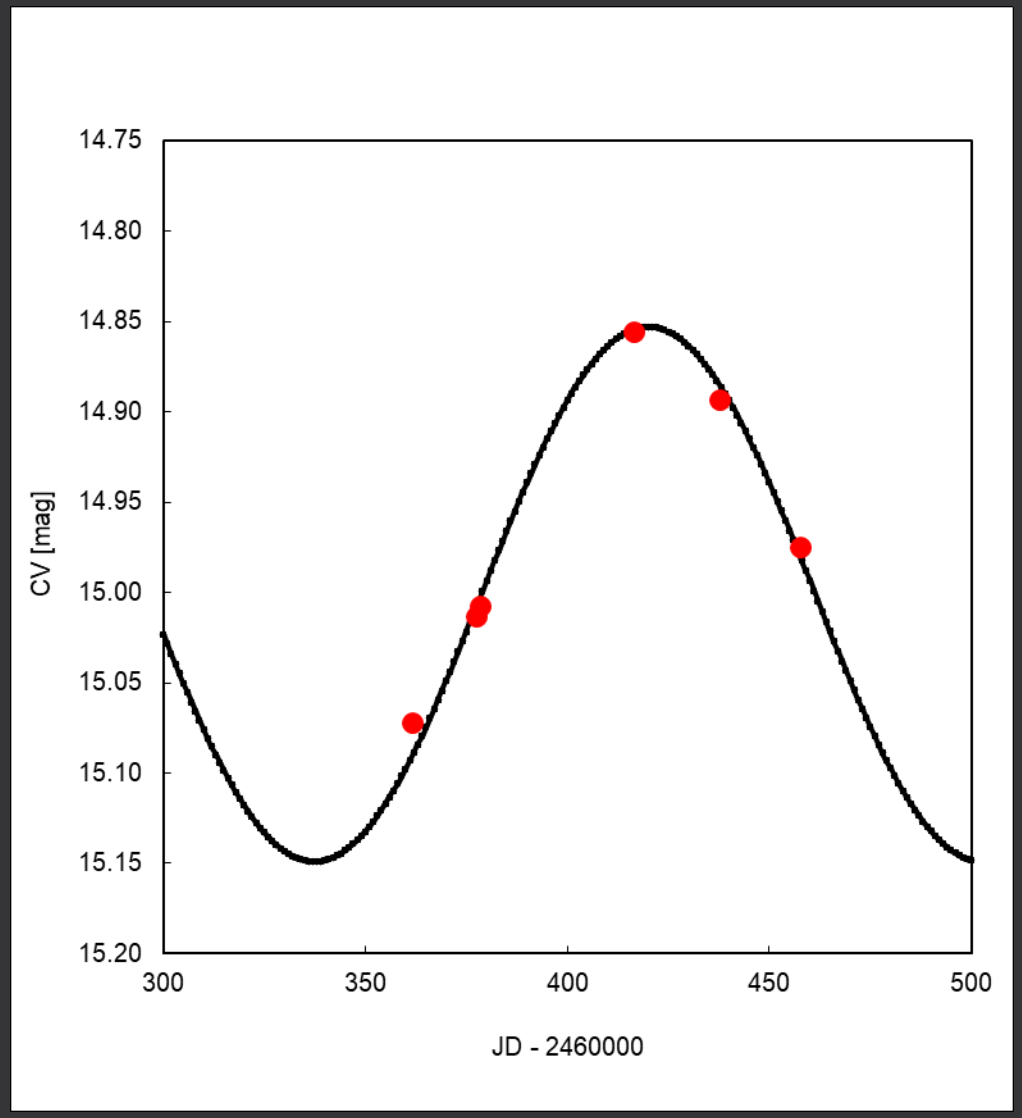

V10
189.3 d
V13
139.0 d
V14
60.5 d
V22
140.1 d
V38
51.5 d
V47
69.0 d
V50
165.2 d
V59
62.1 d
V78
39.5 d
V104
110.2 d
V121
65.1 d
CV [mag]
JD - 2460000



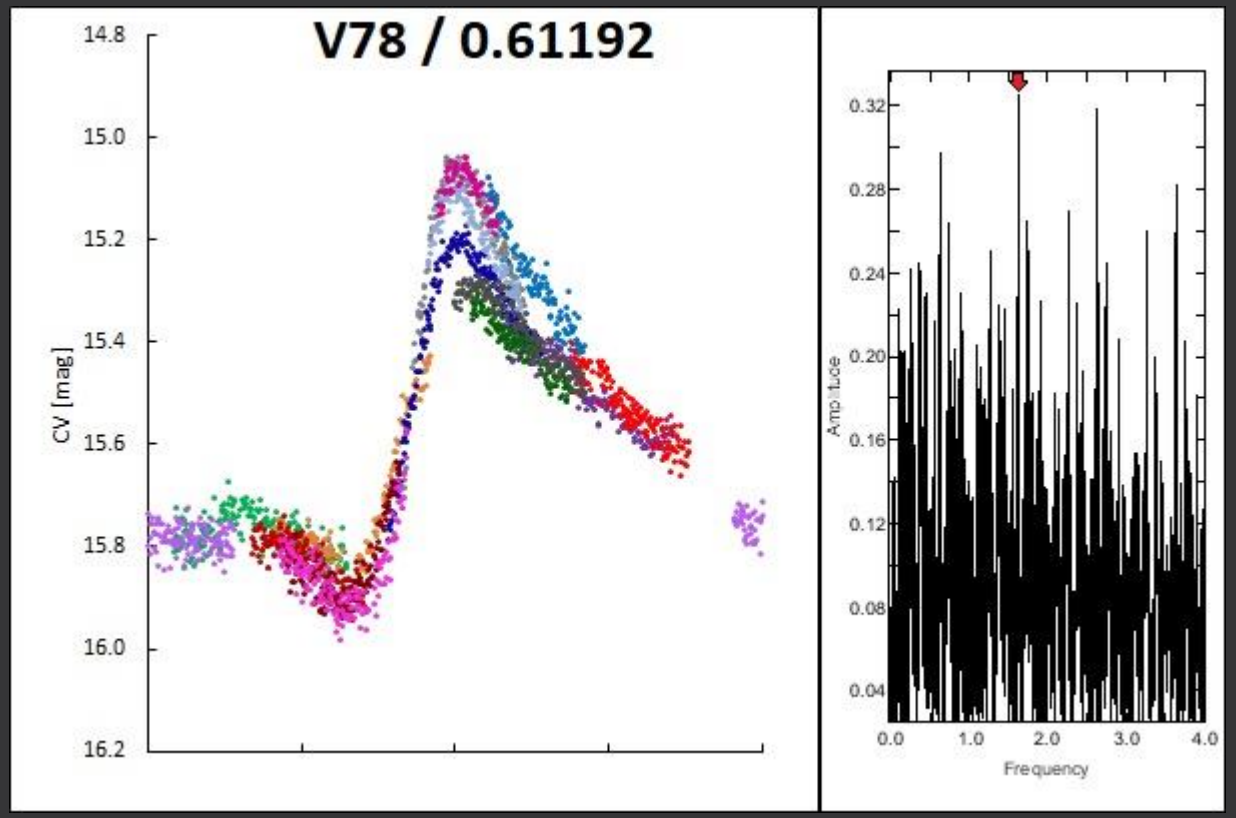


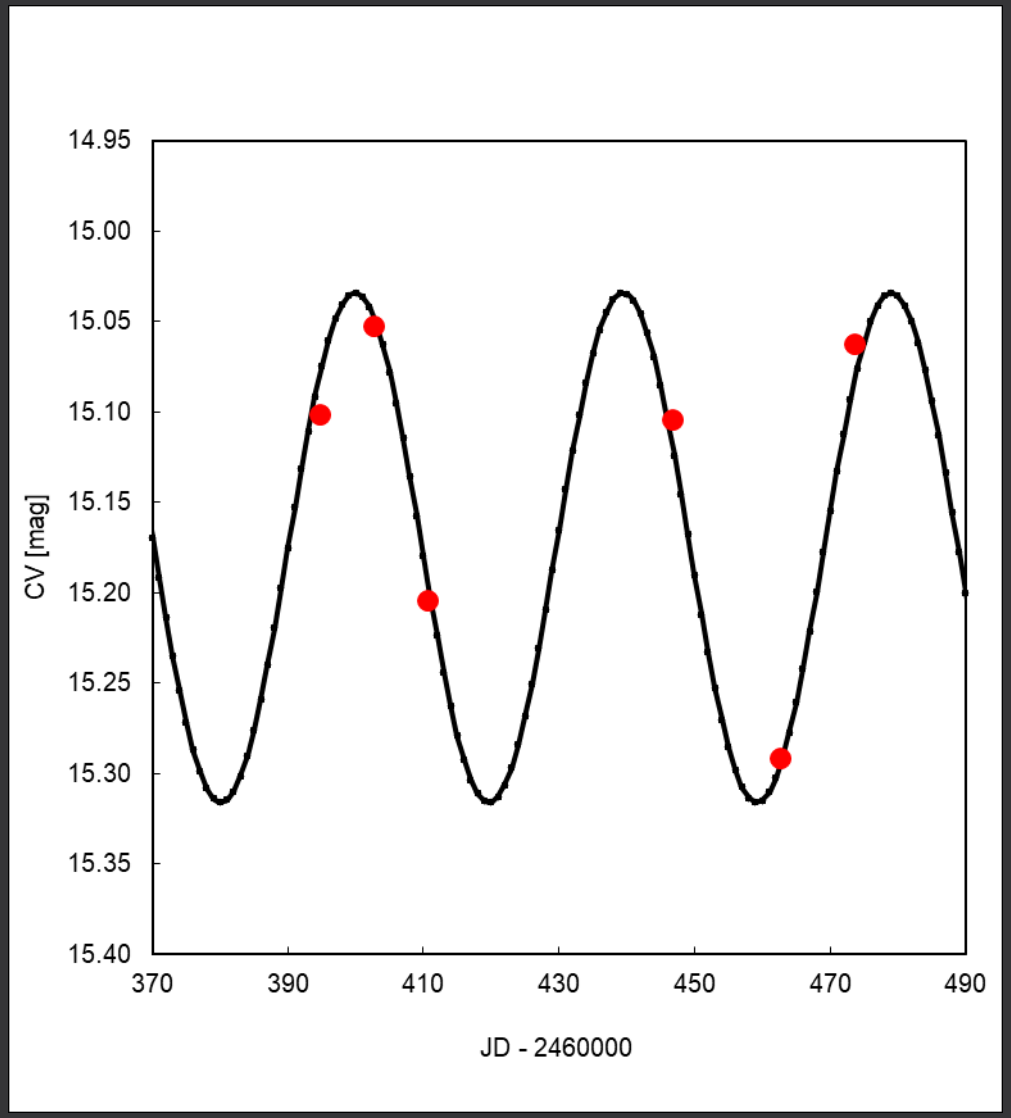
V10 – 189.27 jours



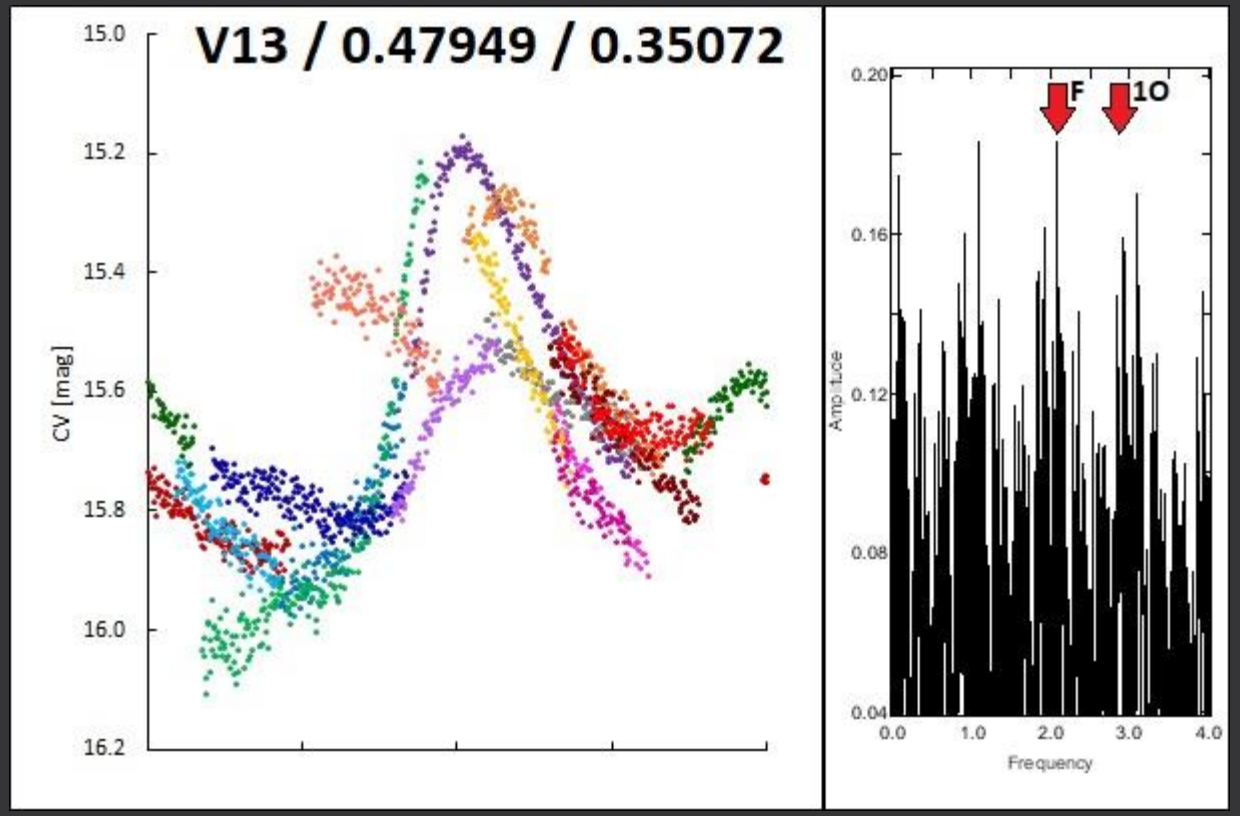


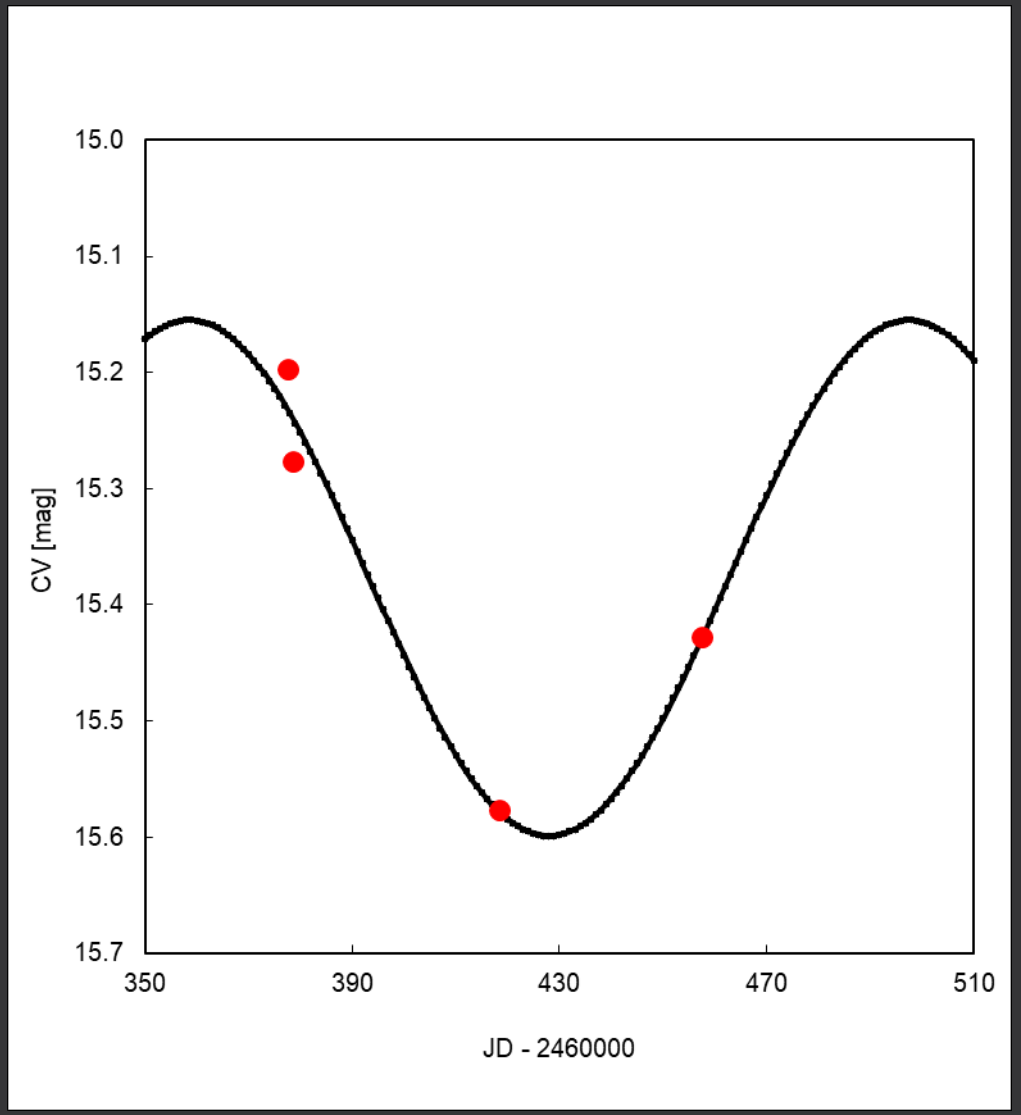
V50 – 165.26 jours





V78 – 39.54 jours



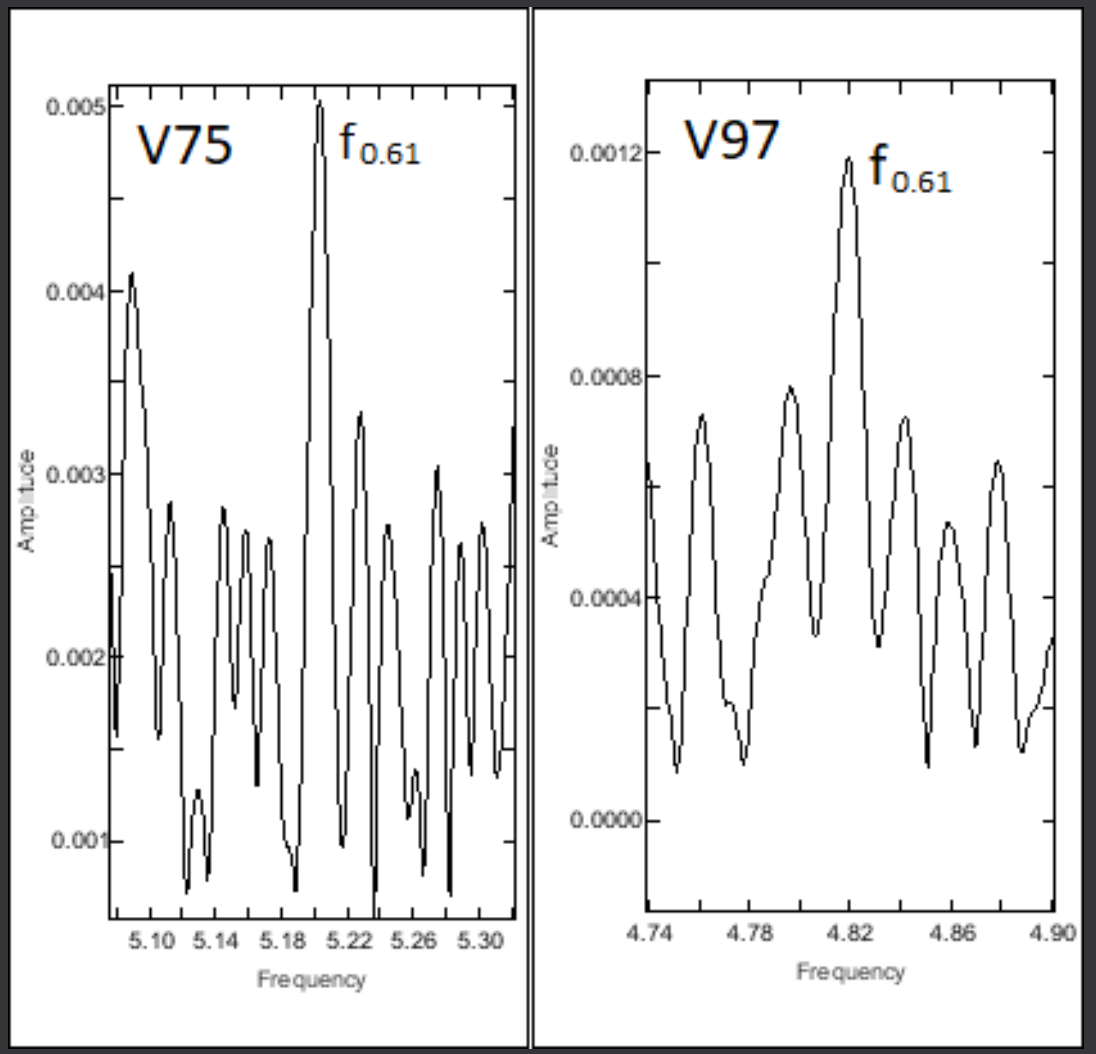


V13 – 138.96 jours

$f_{0.61}$

Table 7. $f_{0.61}$ stars.

ID	f_{1O} (day-1)	A_{1O} (mag)	$f_{0.61}$ (day-1)	$A_{0.61}$ (mag)	$f_{1O}/f_{0.61}$	$A_{0.61}/A_{1O}$ (mag)
V75	3.184017	0.263	5.203256	0.005	0.6119	0.019
V97	2.985369	0.228	4.819178	0.001	0.6195	0.005


V75
$f_{0.61}$
0.005
0.004
0.003
0.002
0.001
Amplitude
5.10 5.14 5.18 5.22 5.26 5.30
Frequency
V97
$f_{0.61}$
0.0012
0.0008
0.0004
0.0000
Amplitude
4.74 4.78 4.82 4.86 4.90
Frequency

Conclusion

Table 8. Observation of 45 RR Lyrae in Messier 3.

ID	Name	# obs.	# night	ID	Name	# obs.	# night
V5	V0467	2747	20	V50	V0377	2107	16
V6	KY	2031	15	V51	V0404	2139	14
V9	IU	1974	14	V52	MP	2144	14
V10	V0457	2319	16	V59	LN	2041	14
V11	KR	2169	16	V67	KU	2173	15
V12	V0361	1370	10	V68	V0394	2573	19
V13	PS	2171	16	V74	V0438	2253	17
V14	NP	2378	17	V75	V0421	2024	14
V16	IR	2234	16	V78	V0420	2206	15
V22	V0464	2646	19	V84	V0428	2213	16
V25	KX	2197	15	V87	V0446	2126	14
V27	LM	1863	14	V89	V0401	861	7
V33	V0431	2395	17	V90	V0443	2012	15
V36	V0461	2212	15	V97	KV	1822	12
V37	KK	1471	10	V99	V0465	2205	16
V38	KN	2462	18	V100	V0430	1554	10
V39	IY	2190	15	V104	OX	2030	14
V40	IV	1974	14	V105	QQ	1942	13
V41	LU	2338	16	V119	V0466	2234	16
V45	IZ	2499	18	V121	NR	1832	12
V47	KZ	1973	14	V125	V0462	1359	9
V48	V0451	1829	13	V166	LS	2246	15
V49	V0454	2120	15				

93658 measurements uploaded in the AAVSO database in August 2024.

Question?