CHAPTER 6

Variable Stars in the Open Cluster NGC 2126

We obtained the instrumental magnitudes using IRAF/DAOPHOT package and measured the differential magnitudes of all the stars in the field of view. We performed a frequency analysis of the light curves of the detected variable stars (see Figures 6.1-6.6) using the Period04 package (Lenz and Breger, 2005) with the prewhitening technique. This technique is an operation that processes a time series (or some other data sequence) to make it behave statistically like white noise. In this procedure, we selected only the peaks with signal-to-noise ratio (S/N) larger than 4 (Breger et al., 1993; Kuschnig et al., 1997). Two stars out of eleven detected variables are newly discovered δ Scuti type pulsating stars according to behaviour of their light curves and their position in the CMD. Among them, we also found the nine variable stars previously discovered by Gáspár et al. (2003) and Zhang et al. (2012). Table 6.4 lists the name of the variable stars from the UCAC4 catalogue, celestial coordinates and visual magnitudes in V and $B-V$. We also mention the period and epoch of maximum light of the variations. In the last column, the classification of all variable stars based on this study. For multi-periodic variables, the frequency analysis suffers from the obvious 1 d^{-1} aliasing phenomenon shown by the secondary peaks offset from the main peak by integer values. It hampers the safe detection of the lower amplitude frequencies, as indicated by the asterisk in Tables 6.2 and 6.3.

6.1 Light Curves of Variable Stars

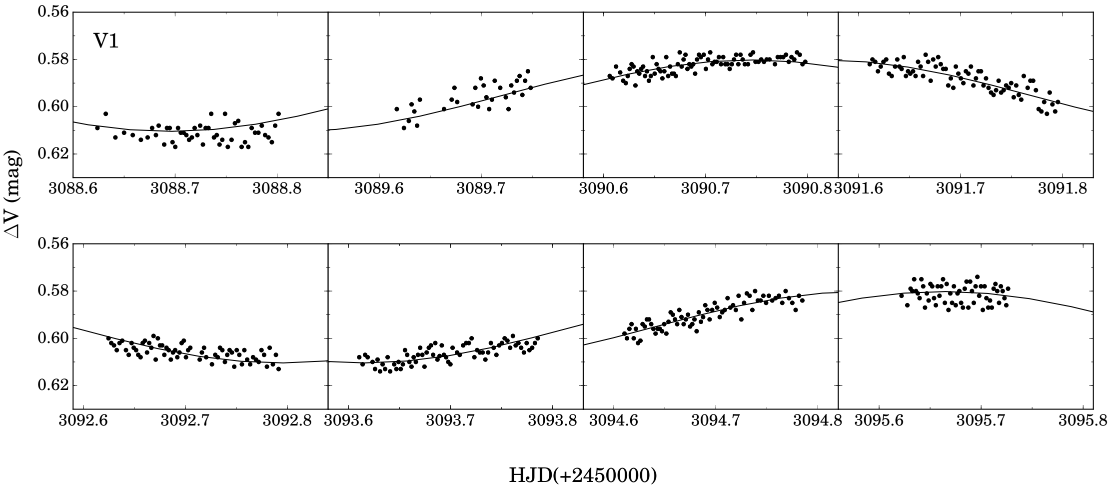

Figure 6.1: Light variations of variable star V1. Synthetics curves computed from our multiple frequency analysis are presented.

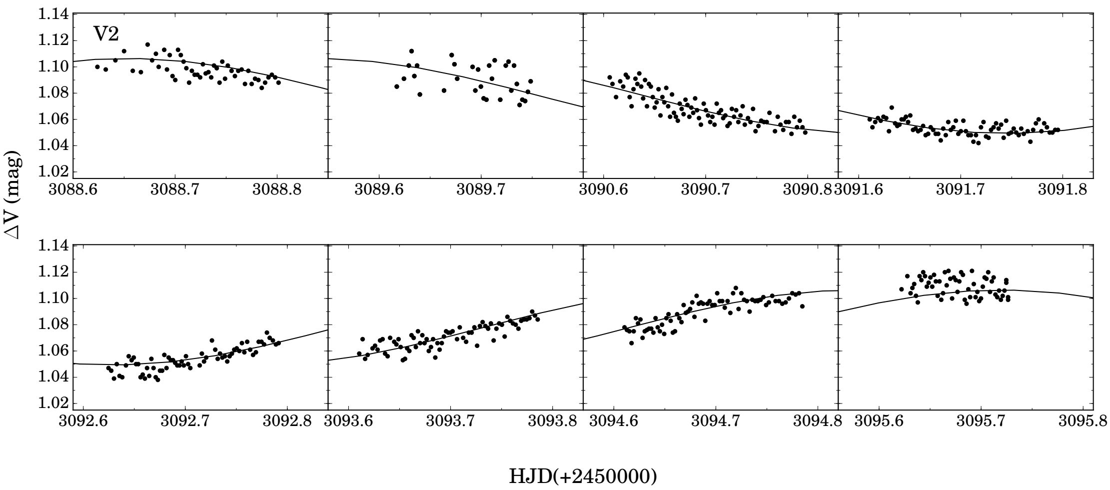

Figure 6.2: Light variations of variable star V2. Synthetics curves computed from our multiple frequency analysis are presented.

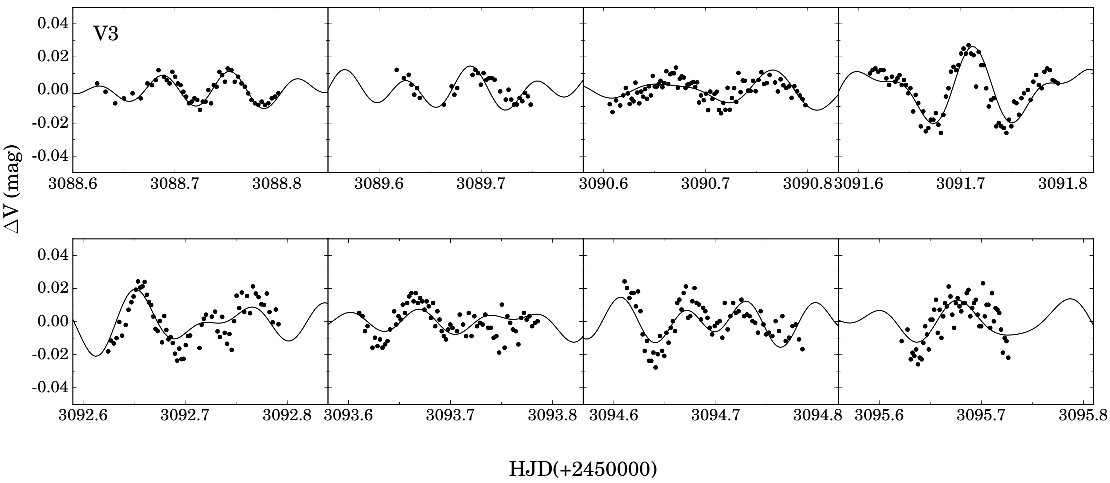

Figure 6.3: Light variations of variable star V3. Synthetics curves computed from our multiple frequency analysis are presented.

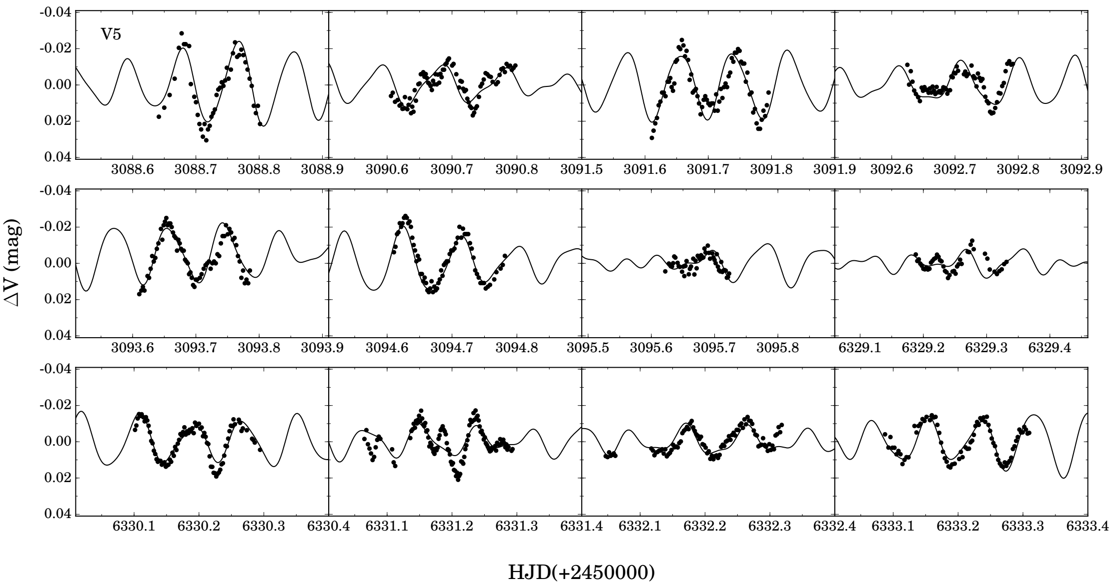

Figure 6.4: Light variations of variable star V5. Synthetics curves computed from our multiple frequency analysis are presented.

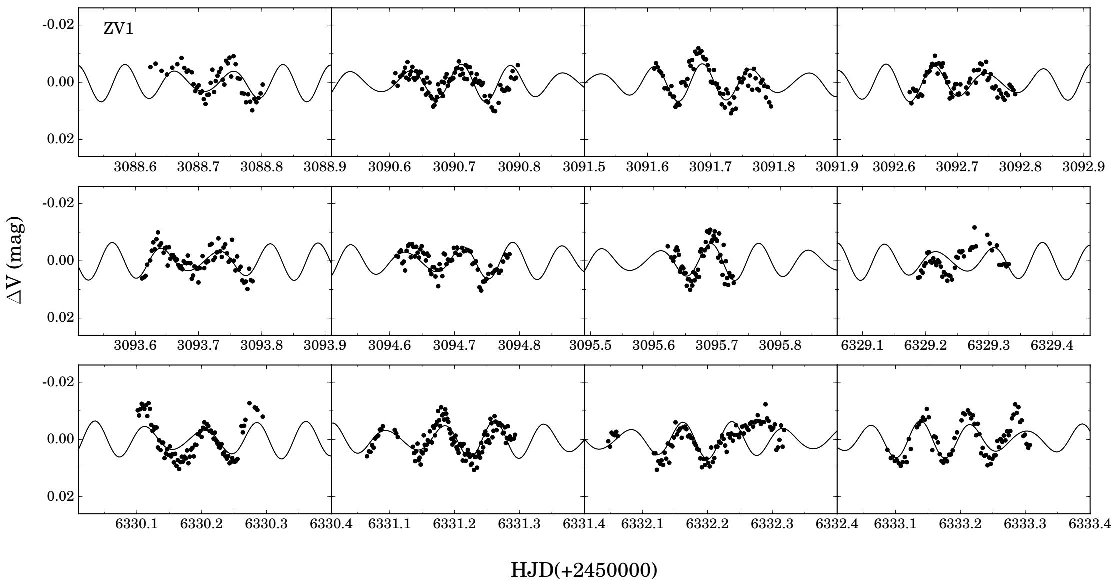

Figure 6.5: Light variations of variable star ZV1. Synthetics curves computed from our multiple frequency analysis are presented.

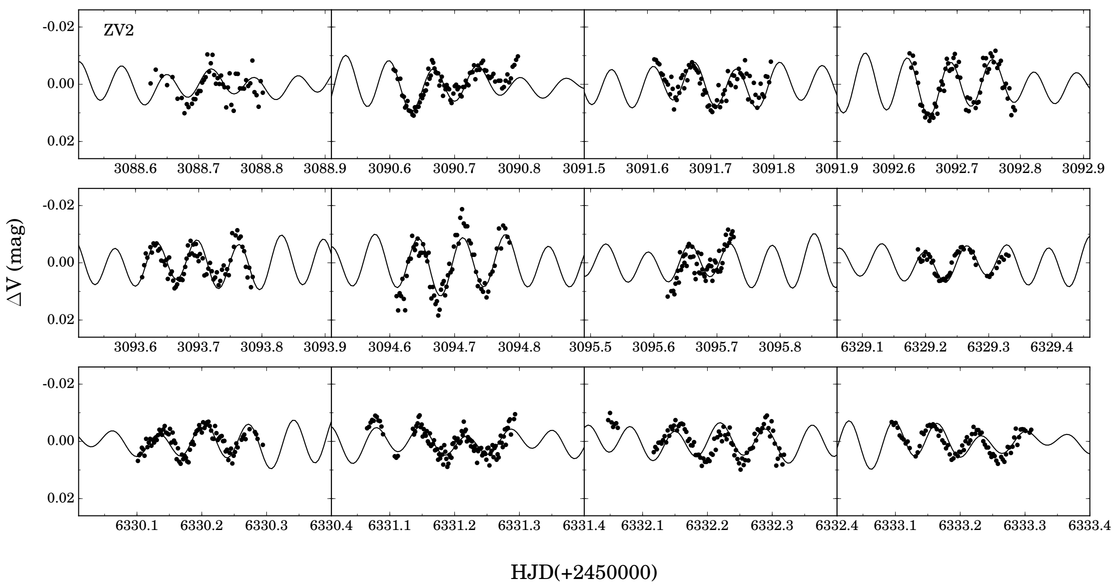

Figure 6.6: Light variations of variable star ZV2. Synthetics curves computed from our multiple frequency analysis are presented.

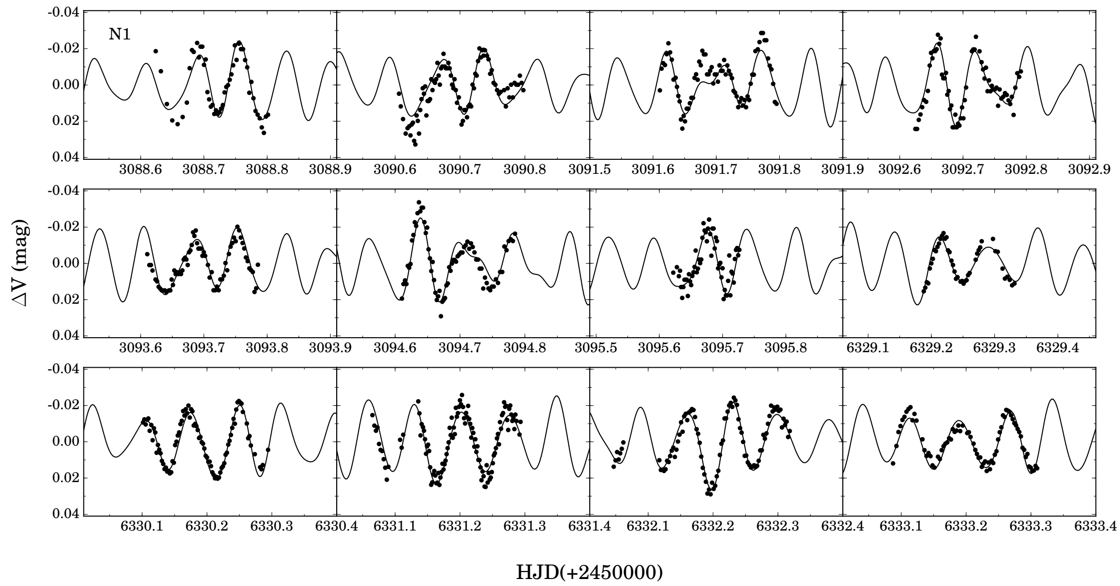

Figure 6.7: Light variations of new variable star N1. Synthetics curves computed from our multiple frequency analysis are presented.

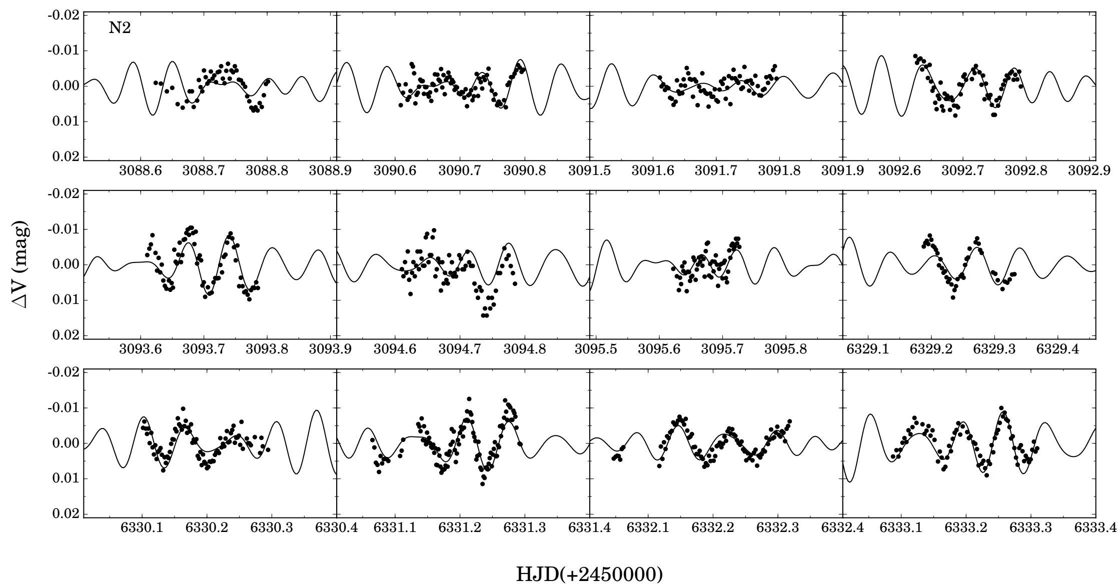

Figure 6.8: Light variations of new variable star N2. Synthetics curves computed from our multiple frequency analysis are presented.

6.2 Monoperiodic variable stars

6.2.1 V546 Aur (V1)

V546 Aur was discovered by Gáspár et al. (2003). They proposed periods of 1.64470 d or half that value, 0.82235 d. Gáspár et al. (2003) suggested that in the case of the cluster membership of V1 its absolute magnitude is M_V = 3.0. Having early F spectral class and the period 0.82235 d, it is in a good agreement with a γ Dor classification. γ Dor stars are early F-type IV, IV-V or V luminosity class stars, with pulsation periods 0.4-3.0 d and V band amplitudes less than 0.1 mag, pulsating in non-radial gravity modes (Kaye et al., 1999). The γ Dor instability strip covers the 6900-7500 K temperature range and extends one magnitude above the ZAMS (Handler, 1999). On the other hand, in the case of field star and P = 1.6447 d they suggested that its double-peaked light curve can be typical for the spotted RS Canum Venaticorum (RS CVn) stars. Liu et al. (2009) obtained two periods of V1, 0.82222 d and 1.64444 d and suggested that V1 may be γ Dor star rather than a RS CVn. We obtained the data of V546 Aur in V band in the year 2004 as shown in frame A in Figure 3.7. The main frequency of the star was detected to be f = 1.2198 $\pm$ 0.0011 c/d as shown in Table 6.1. The period of V1 is 0.8198 d or its double value. On the CMD in Figure 6.9, V1 fits well the isochrone of the cluster. Considering all observable parameters, including the absolute magnitude, the spectral class and the pulsation period we suggest the γ Dor classification of this variable.

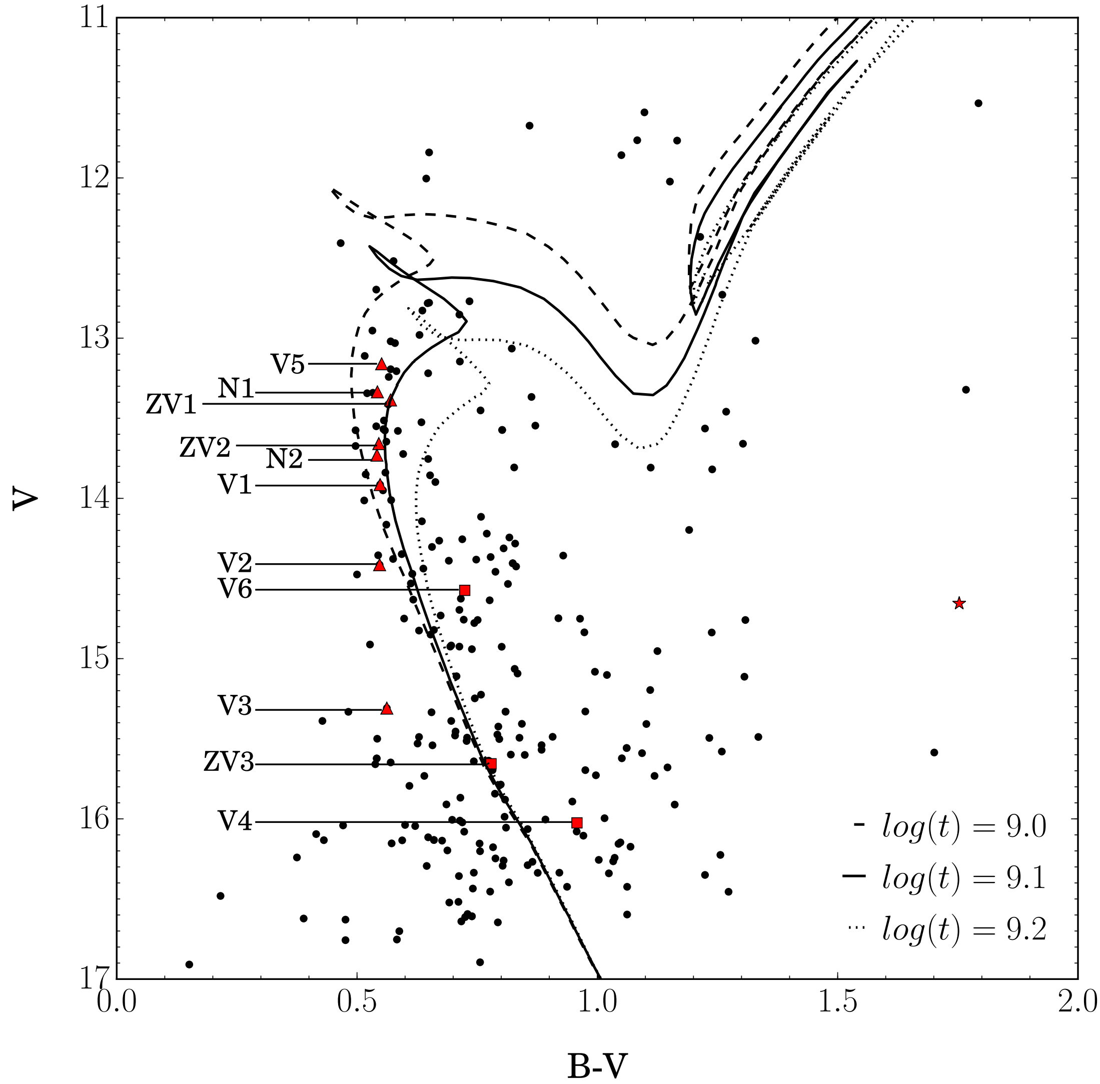

Figure 6.9: Colour-magnitude diagram for the stars in NGC 2126. Red filled triangles represent the pulsating stars, red filled squares represent eclipsing binary and red star represents the high proper motion star in the cluster. Isochrones from Bressan et al. (2012) are plotted with dashed line, full line and dot-dashed line for log(age) = 9.0, 9.1 and 9.2 yrs, respectively.

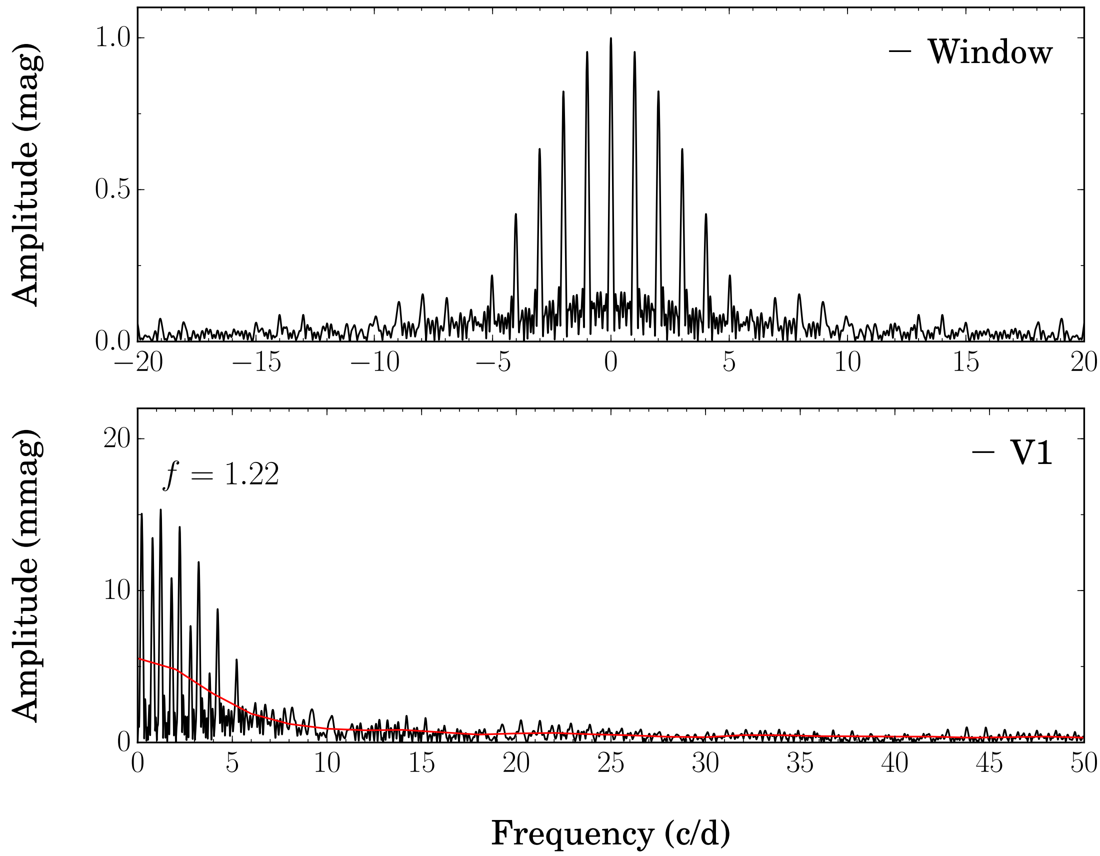

Figure 6.10: Amplitude spectrum of the long period variable star V1 and the noise level (red line). Window spectrum is shown at the top.

6.2.2 V547 Aur (V2)

Gáspár et al. (2003) obtained two possible periods of V2 around 0.5 d and 1 d but did not decide about the type of variability due to an incomplete light curve. Liu et al. (2009) also did not find accurate variability period. We obtained the data of V547 Aur in V band in the year 2004 as shown in frame A in Figure 3.7. From a Fourier analysis, we detect the main frequency of f = 1.1321 $\pm$ 0.0012 c/d and propose a period of 0.8833 d or its double value (see Figure 6.11 and Figure 6.18). The position of V2 on CMD is in good agreement with cluster membership and Main-Sequence location, $(B - V)_0$ = 0.28 corresponds to a F0 spectral class. In summary, we suggest a classification of γ Dor type.

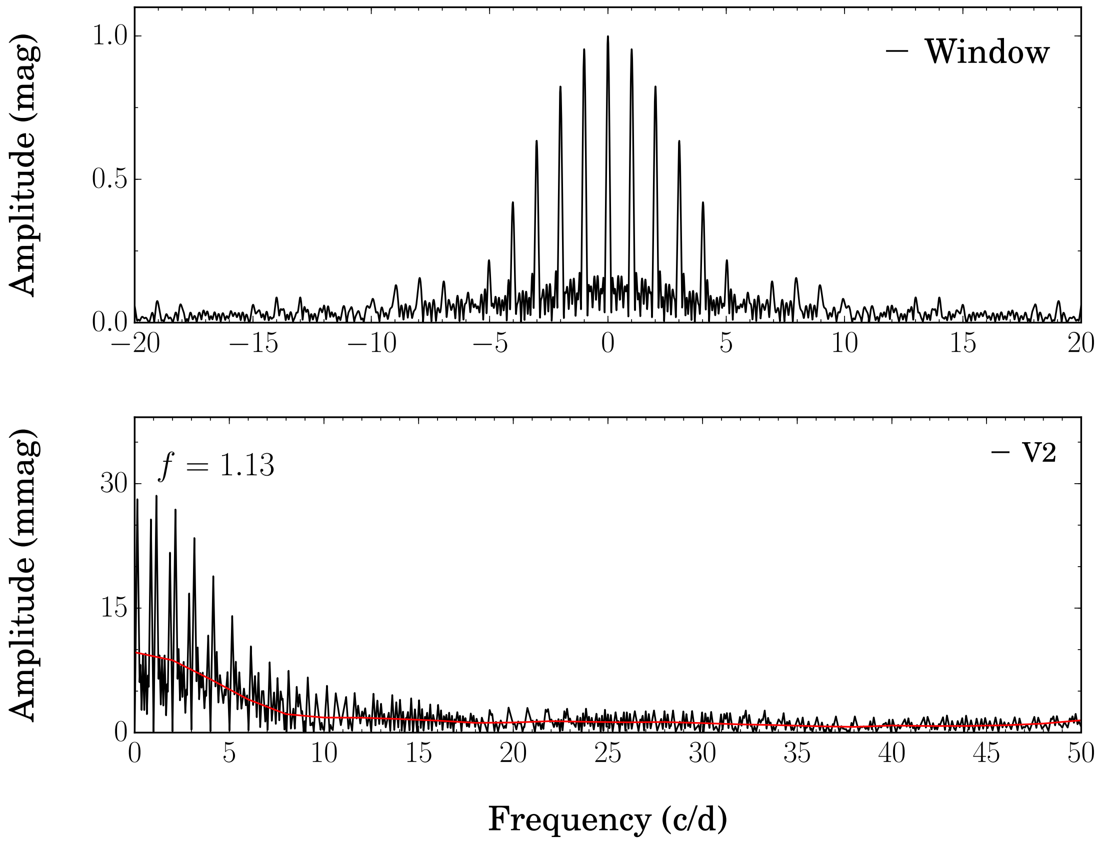

Figure 6.11: Amplitude spectrum of the long period variable star V2 and the noise level (red line). Window spectrum is shown at the top.

Table 6.1: Results of the frequency-fit to the V light curve of monoperiodic variable stars V1 and V2. The signal-to-noise ratio (S/N) of the peak is much larger than 4 following Breger et al. (1993); Kuschnig et al. (1997).

Stars	Frequency (c/d)	Amplitude (mmag)	Phase (rad)	S/N
V1	1.2198 ± 0.0011	15.1 ± 0.2	0.716 ± 0.002	30.81
V2	1.1321 ± 0.0012	28.5 ± 0.4	0.555 ± 0.002	23.74

6.3 Multi-periodic Variables

6.3.1 V548 Aur (V3)

Gáspár et al. (2003) considered that V548 Aur (or V3 according to their identification) is a multi-periodic δ Scuti variable star. The location of V3 on cluster's CMD is shown in Figure 6.9. It seems to be a background star as its absolute visual magnitude places it well below the cluster's Main Sequence. Five frequencies with S/N ratios larger than 4 were identified during the analysis (see Figure 6.12), their frequencies and amplitudes with their errors are given in Table 6.2. The dominant frequency is $f_1 = 15.874041$ c/d and the amplitude of 6.9 mmag. Gáspár et al. (2003) found two frequencies: the dominant 10.39 c/d (6.7 mmag amplitude) and 12.79 c/d (6.5 mmag amplitude). The first one is close to 10.572958 c/d found in the present work, note that the amplitudes of the first two modes are almost identical. The second one could be a 2 d^{-1} alias frequency of f_4. It is evident that the frequency spectrum shows evidence for the variability of the amplitudes and/or frequencies between the years 2002 and 2004.

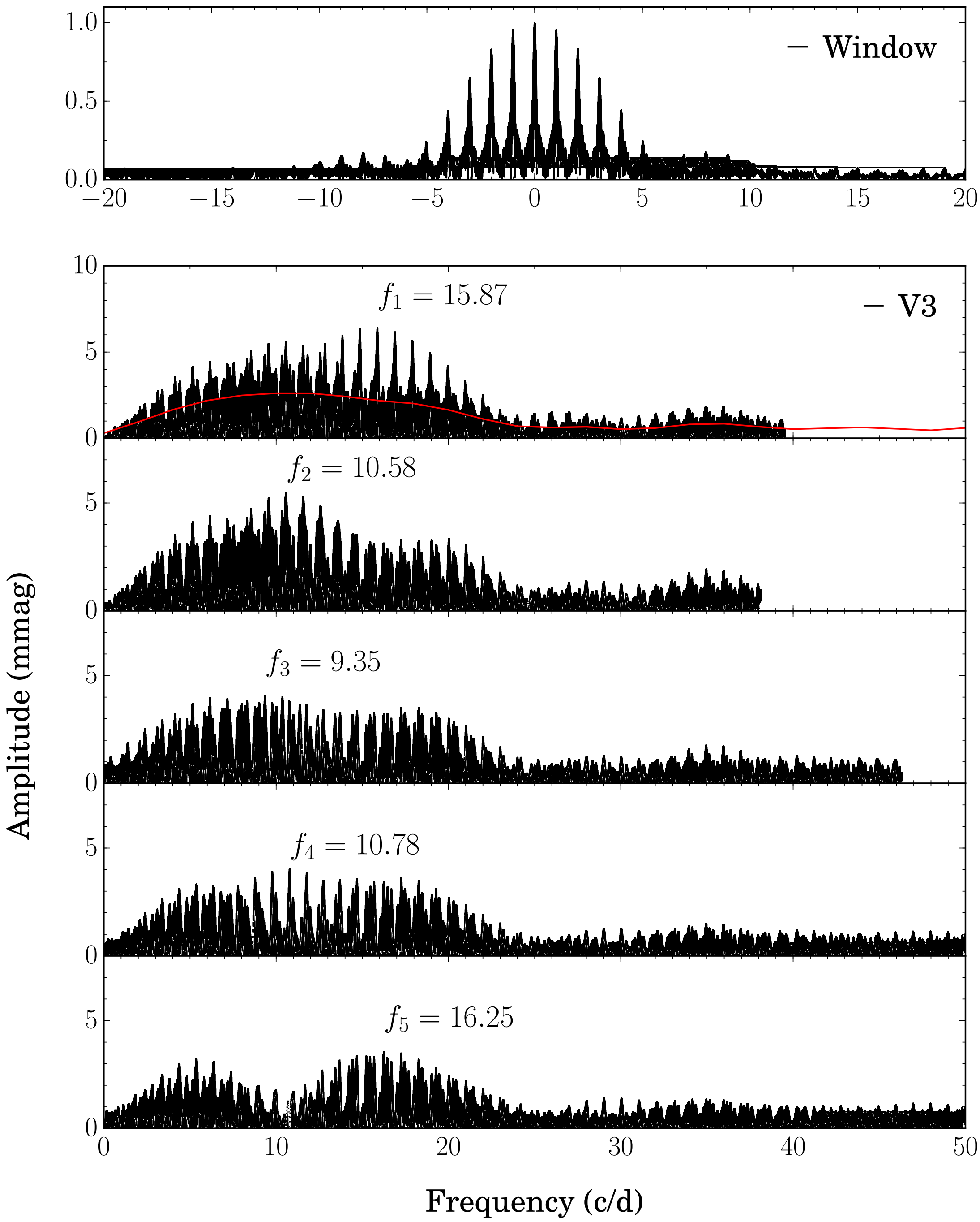

Figure 6.12: Amplitude spectrum of the multi-periodic δ Scuti V3 and the noise level (red line). Window spectrum is shown at the top.

6.3.2 V550 Aur (V5)

Gáspár et al. (2003) discovered the new variable star V5 which showed rapid oscillations. The highest amplitudes of the star is around tens of millimags (mmag), which is characteristic of δ Scuti variables. They identified two frequencies in its light curves f_1 = 11.43 c/d and f_2 = 12.14 c/d. Gáspár et al. (2003) proposed that V5 is probably multi-periodic pulsating δ Scuti variable. They suggested that the star contains more frequencies due to small oscillations in the light curves and structures of residual in the spectra. Liu et al. (2009) presented the main frequency of V5 to be 12.09 c/d which is close to f_2 in our study. The position of V5 on CMD is in agreement with cluster membership and Main-Sequence location, $(B - V)_0$ = 0.28 corresponds to the F0 spectral class. Seven frequencies were detected in V5 as shown in Table 6.2 and Figure 6.13. The dominant frequency of 11.443147±0.000003 c/d is consistent with the value from Gáspár et al. (2003). We may safely conclude that V5 is a multi-periodic δ Scuti star.

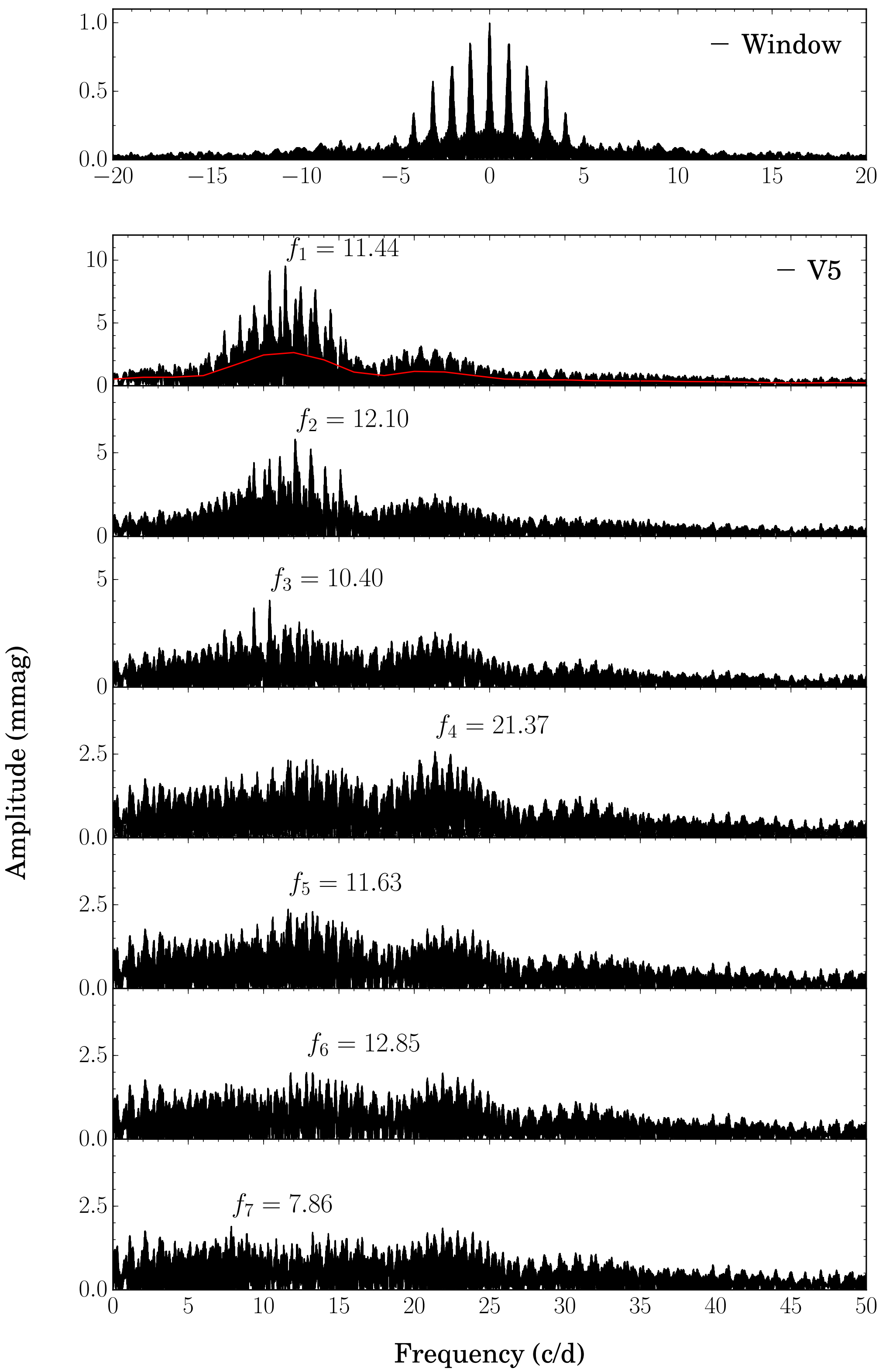

Figure 6.13: Amplitude spectrum of the multi-periodic δ Scuti V5 and the noise level (red line). Window spectrum is shown at the top.

6.3.3 ZV1

ZV1 was discovered by Zhang et al. (2012). They proposed that ZV1 is δ Scuti star with a period of about 2 hr and amplitudes around 0.02 mag. From Fourier analysis in B-and V-band data, two significant frequencies were found, they could be caused by intrinsic oscillations (i.e. pulsations). The isochrone analysis is used to estimate the cluster parameters. Assuming that ZV1 is a member of the cluster, they estimated the physical parameters of the star including its effective temperature, mass, and luminosity, and hence the mean density. They also calculated the pulsating constant for pulsating frequency. In present study, the position of V5 on CMD is in agreement with a cluster membership and Main-Sequence location, $(B-V)_0$ = 0.30 corresponds to F0 spectral class. Figure 6.14 displays the successive spectra of the star from our V data. Two frequencies were detected in ZV1 as shown in Table 6.2. The main frequency is f_1 = 12.251922$\pm$0.000005 c/d and f_2 = 15.456339$\pm$0.000014 c/d which are consistent with the frequencies from Zhang et al. (2012). We confirm that ZV1 is a multi-periodic δ Scuti star.

6.3.4 ZV2

ZV2 (GSC3382-0957) was discovered by Zhang et al. (2012), it seems be an unusual pulsator. The star exhibits a complex pattern of light variations with short-term periodic oscillations. In addition, the star also have long-term variations from night to night. Zhang et al. (2012) proposed the power spectral analysis of B band data and two pulsation frequencies are detected at f_1 = 14.835 (c/d) and f_2 = 1.812 (c/d), respectively. The lower frequency corresponds to a g-mode and the higher one can be identified as a p-mode. The star lies almost at the overlapping area between two types of pulsating variables, the γ Dor and δ Sct stars in the CMD. They suggested that ZV2 could be a probable hybrid γ Dor-δ Scuti. Moreover, ZV2 is very likely a member of the open cluster. The study in detail of the cluster and other members provides physical properties and evolutionary status of the star. This would make the star a very crucial object for the study of the stellar interiors and asteroseismology. The γ Dor-type stars commonly pulsate in one day periods, it is most difficult to obtain heir frequencies unambiguously due to the aliasing linked to single-site ground-based observations. In our data, we detected four frequencies as shown in Table

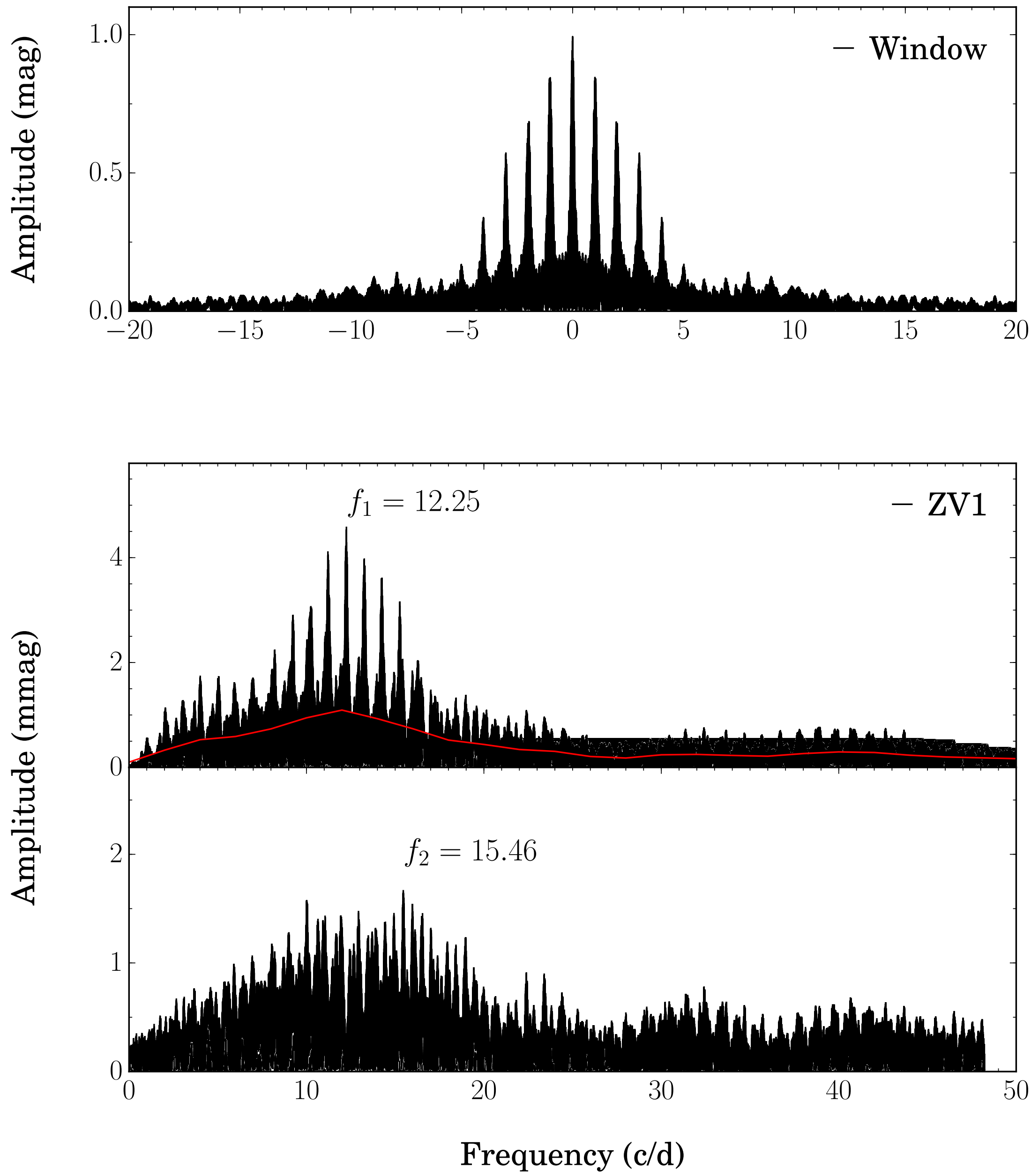

Figure 6.14: Amplitude spectrum of the multi-periodic δ Scuti ZV1 and the noise level (red line). Window spectrum is shown at the top.

6.2. The main frequency is f_1 = 14.847198±0.000004 c/d which is very consistent with the most dominant frequency from Zhang et al. (2012).

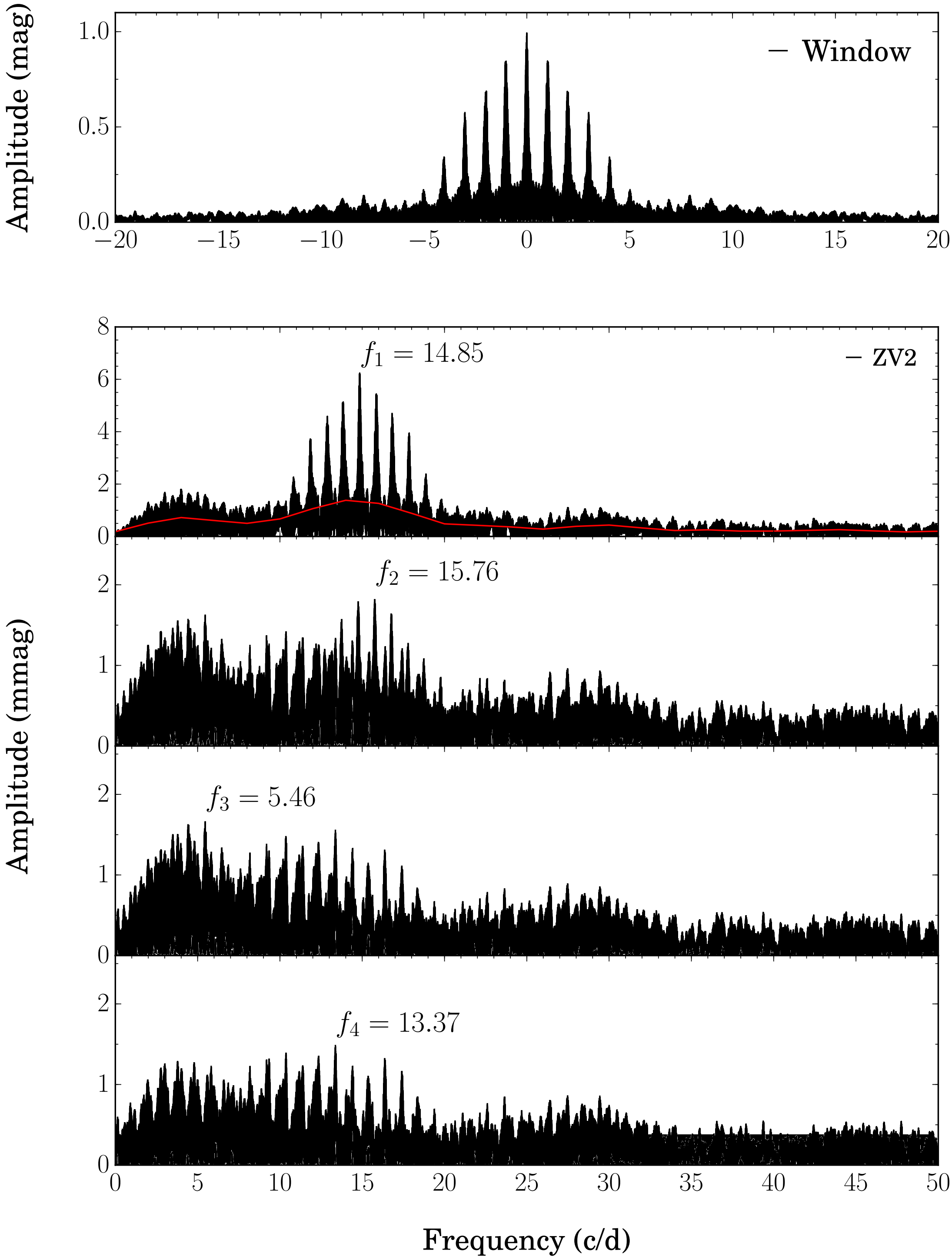

Figure 6.15: Amplitude spectrum of the multi-periodic δ Scuti ZV2 and the noise level (red line). Window spectrum is shown at the top.

Table 6.2: Results of the frequency-fit to the V light curves of the multi-periodic variable stars. The signal-to-noise ratio (S/N) of the peaks is larger than 4 following Breger et al. (1993); Kuschnig et al. (1997).

ID	f_i	Frequency (c/d)	Amp. (mmag)	Phase (rad)	S/N
V3	f_1	15.874041±0.000008	6.9±0.4	0.338 ±0.009	7.08
	f_2	10.572958±0.000008	6.6±0.4	0.761 ±0.009	7.63
	f_3	9.353392±0.000009*	5.6±0.4	0.252 ±0.011	6.71
	f_4	10.780440±0.000010*	5.2±0.4	0.176 ±0.012	5.42
	f_5	16.250492±0.000013*	3.9±0.4	0.350 ±0.015	3.97
V5	f_1	11.443147±0.000003	7.8±0.2	0.530±0.004	15.37
	f_2	12.097190±0.000005	5.4±0.2	0.365±0.006	10.93
	f_3	10.399314±0.000006	4.3±0.2	0.734±0.008	8.91
	f_4	21.370194±0.000011	2.5±0.2	0.500±0.013	3.70
	f_5	11.629984±0.000011*	2.5±0.2	0.600±0.013	4.87
	f_6	12.849580±0.000011*	2.5±0.2	0.324±0.013	4.58
	f_7	7.858146±0.000014*	2.0±0.2	0.744±0.016	4.43
ZV1	f_1	12.251922±0.000005	5.0±0.2	0.634±0.006	10.66
	f_2	15.456339±0.000014	1.8±0.2	0.622±0.016	3.92
ZV2	f_1	14.847199±0.000004	6.2±0.2	0.975±0.004	19.61
	f_2	15.757932±0.000011	2.2±0.2	0.471±0.012	7.06
	f_3	5.460764±0.000015	1.6±0.2	0.956±0.017	5.01
	f_4	13.369917±0.000015	1.6±0.2	0.610±0.017	4.95

*Frequency values are probably ambiguous due to the 1 day^{-1} aliasing.

6.4 New Variables

6.4.1 Variable star N1

We discovered the new variable star N1. The observations were collected in the V-band during the three campaigns as shown in Figure 3.7. Using Fourier analysis and the prewhitening technique, nine-frequencies are detected as shown in Table 6.3. Figure 6.16 displays the power spectra. The light curve indicates that it is a multi-periodic variable star (see Figure 6.7) with the dominant frequency of 13.597445±0.000002 c/d and the amplitude 15.6 mmag. Its colour index $(B-V)_0$ = 0.27 corresponds to the F0 spectral class. The spectral type of star is located in the instability strip (Breger, 2000). N1 might be a multi-periodic δ Scuti star.

6.4.2 Variable star N2

We discovered the new variable star N2. Its light curves indicate that it is multi-periodic variable star (see Figure 6.8) with the main frequency of 14.552467±0.000006 c/d and the amplitude of 3.7 mmag. Six frequencies are detected by Fourier Analysis and prewhitening technique as shown in Table 6.3. The position of N2 is in agreement with a cluster membership and $(B - V)_0$ = 0.27 corresponds to the F0 spectral class, thus it is also located in the instability strip (Breger, 2000). Considering its absolute magnitude, the spectral class and the pulsation period we propose that it is belongs to the class of the δ Scuti stars.

Table 6.3: Results of the frequency-fit to the V light curve of new variable stars N1 and N2. The signal-to-noise ratio (S/N) of the peak is larger than 4 following Breger et al. (1993); Kuschnig et al. (1997).

ID	f_i	Frequency (c/d)	Amp. (mmag)	Phase (rad)	S/N
N1	f_1	13.597445±0.000002	15.6±0.2	0.562±0.002	35.31
	f_2	17.173266±0.000008	3.6±0.2	0.714±0.010	8.24
	f_3	4.009167±0.000013	2.4±0.2	0.451±0.015	4.54
	f_4	21.233362±0.000010	3.2±0.2	0.145±0.011	8.23
	f_5	7.592614±0.000014	2.2±0.2	0.290±0.016	4.78
	f_6	14.870599±0.000014*	2.2±0.2	0.955±0.016	5.80
	f_7	15.544526±0.000015*	2.0±0.2	0.235±0.017	5.59
	f_8	22.203415±0.000015*	2.0±0.2	0.022±0.017	5.83
	f_9	21.827054±0.000018*	1.7±0.2	0.881±0.021	4.74
N2	f_1	14.552467±0.000006	3.7±0.2	0.174±0.006	13.64
	f_2	15.284740±0.000010	2.1±0.2	0.647±0.011	7.77
	f_3	19.073477±0.000014	1.4±0.2	0.586±0.017	5.76
	f_4	11.794418±0.000014	1.5±0.2	0.846±0.016	5.63
	f_5	18.647544±0.000015*	1.4±0.2	0.025±0.017	5.81
	f_6	14.086533±0.000016*	1.2±0.2	0.933±0.019	4.44

*Frequency values are probably ambiguous due to the 1 day^{-1} aliasing.

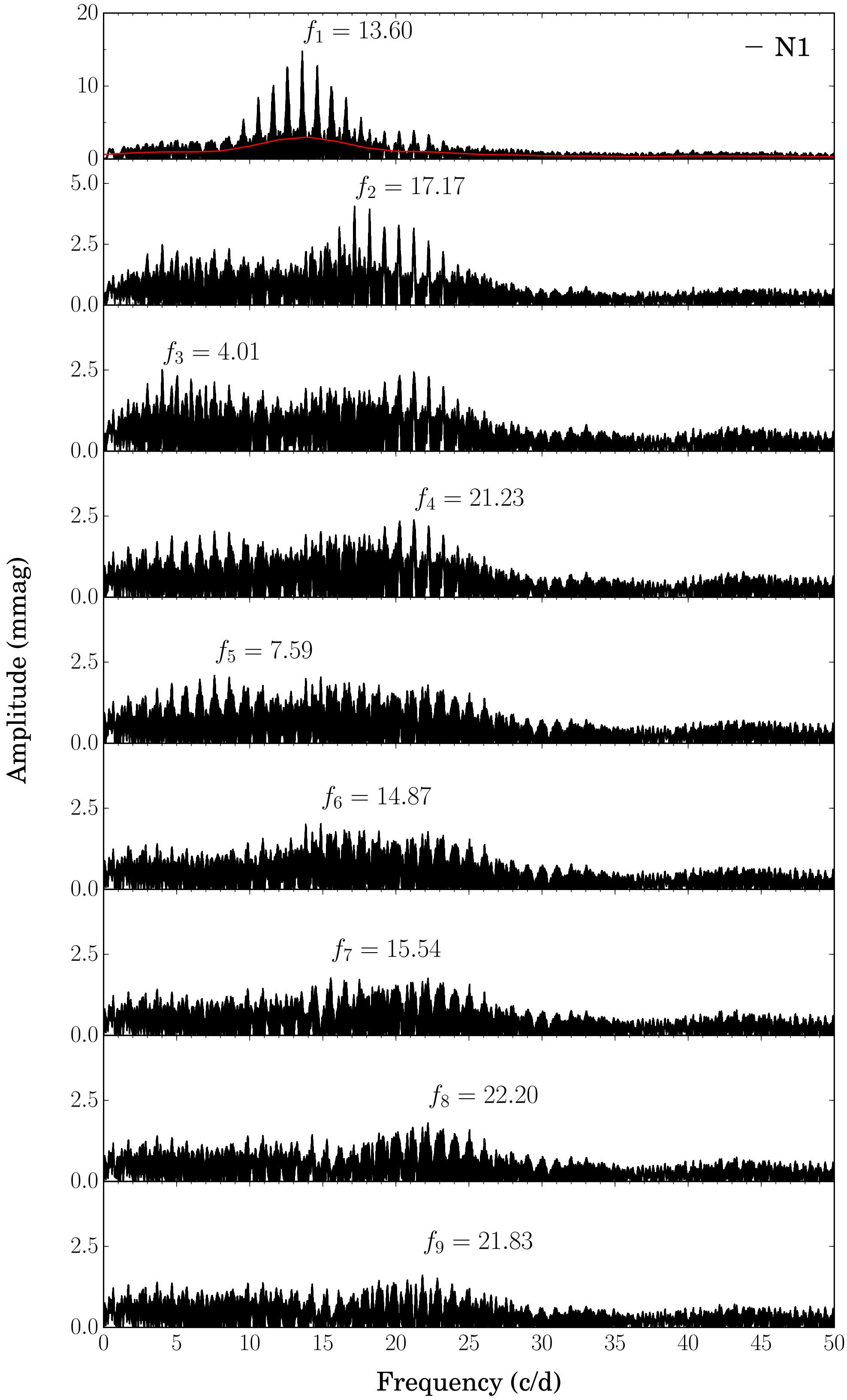

Figure 6.16: Amplitude spectrum of new discovered δ Scuti-type star N1.

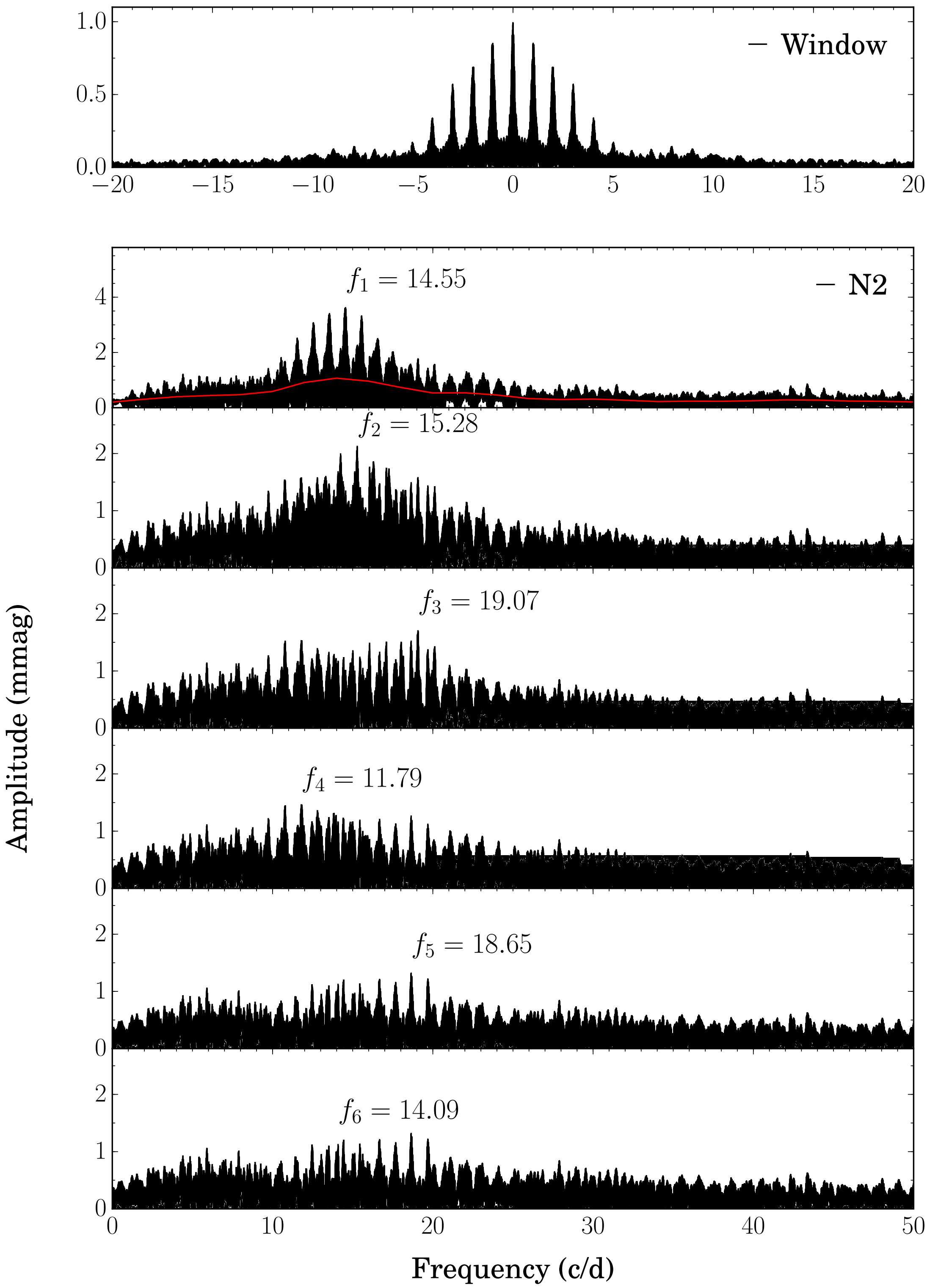

Figure 6.17: Amplitude spectrum of new discovered δ Scuti-type star N2. Window spectrum is shown at the top.

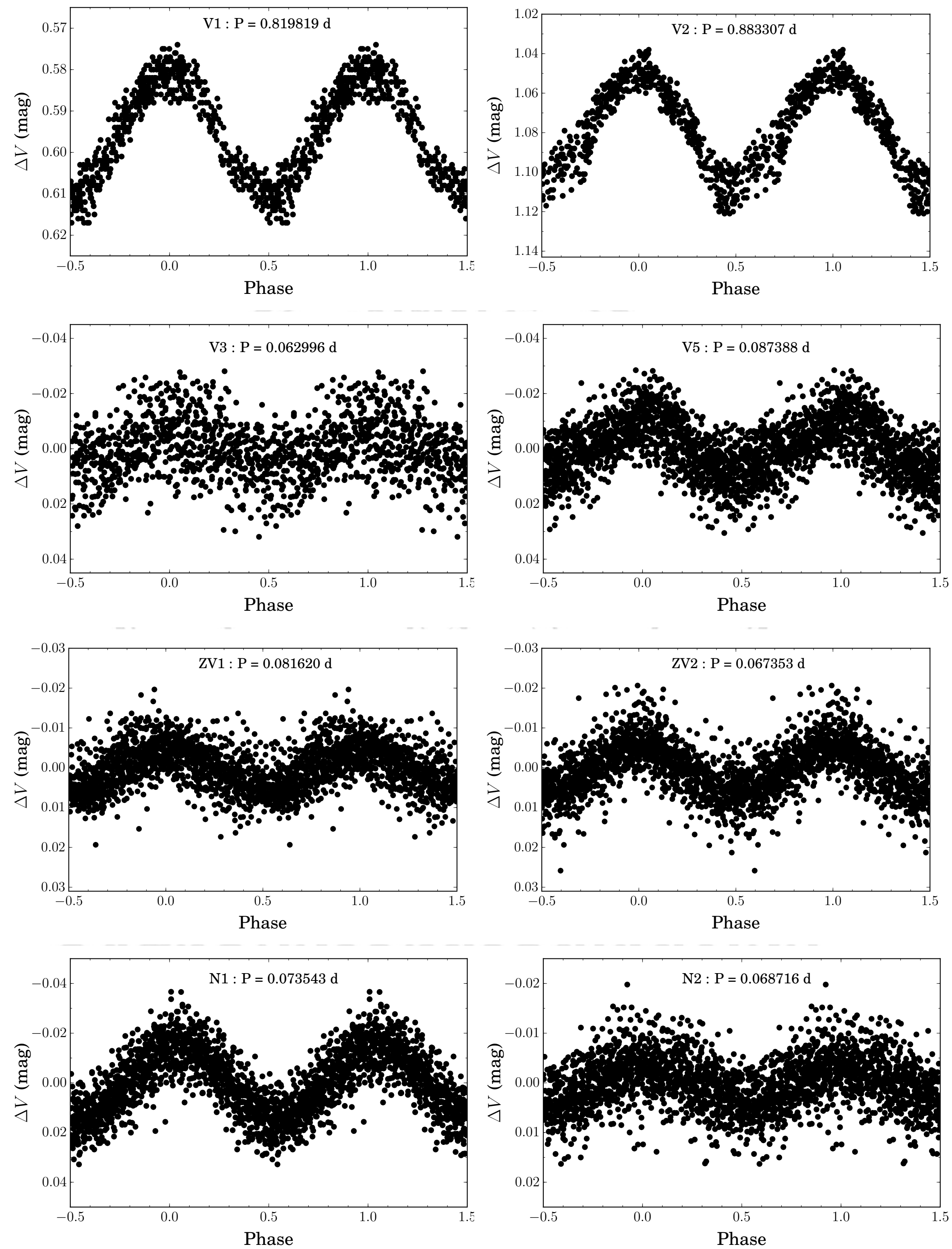

Figure 6.18: Phase diagrams are showing two periods of eight new and known pulsating variables (V1, V2, V3, V5, ZV1, ZV2, N1, N2).

6.5 Eclipsing binaries

6.5.1 V549 Aur (V4)

V549 Aur or V4 is an Algol-type eclipsing binary which is a semi-detached system in which one component transfers mass unto the other due to filling its Roche lobe. Gáspár et al. (2003) observed only one timing of light minimum of this star (HJD 2452308.387) and could not determine its period. The shape of its light curve suggests a clearly visible reflection effect (about 0.1 mag). Assuming symmetry around the unobserved secondary minimum, they estimated a period of $\sim$3 d. Liu et al. (2009) observed three eclipses. They obtained a probable period of 1.0966 d. In addition, they determined its spectral type to be F-type. In this study, a partial eclipse was detected on 9th February 2013 as shown in Figure 6.20. The orbital period of the system could not be determined from our data due to the limited data set. Unfortunately, we could not access the data from Liu et al. (2009) to make a complete analysis. In order to improve the orbital period, we plotted the phased light curve combined with the one minimum observed by Gáspár et al. (2003) varying the orbital period and epoch around the period given by Liu et al. (2009) in order to find the best match for this data set spanning 12 years. The new ephemeris Min I $= 2452308.383560 + 1.096637E$ was found. The combined phased curve is shown in Figure 6.19.

6.5.2 ZV3

Zhang et al. (2012) discovered the new variable star ZV3 which is an eclipsing binary of the cluster. The shape of its eclipses suggest that it could be of Algol (EA) type. In our study, half of a light minimum is apparent on 8th February 2013 as shown in Figure 6.20. Due to the limited size of the data, we could not determine the orbital period of the system. Since about half of primary minimum time interval spans a duration of 0.07 d, we can estimate that the orbital period of this system lies between 1 and 1.5 d. This has to be confirmed by future observations.

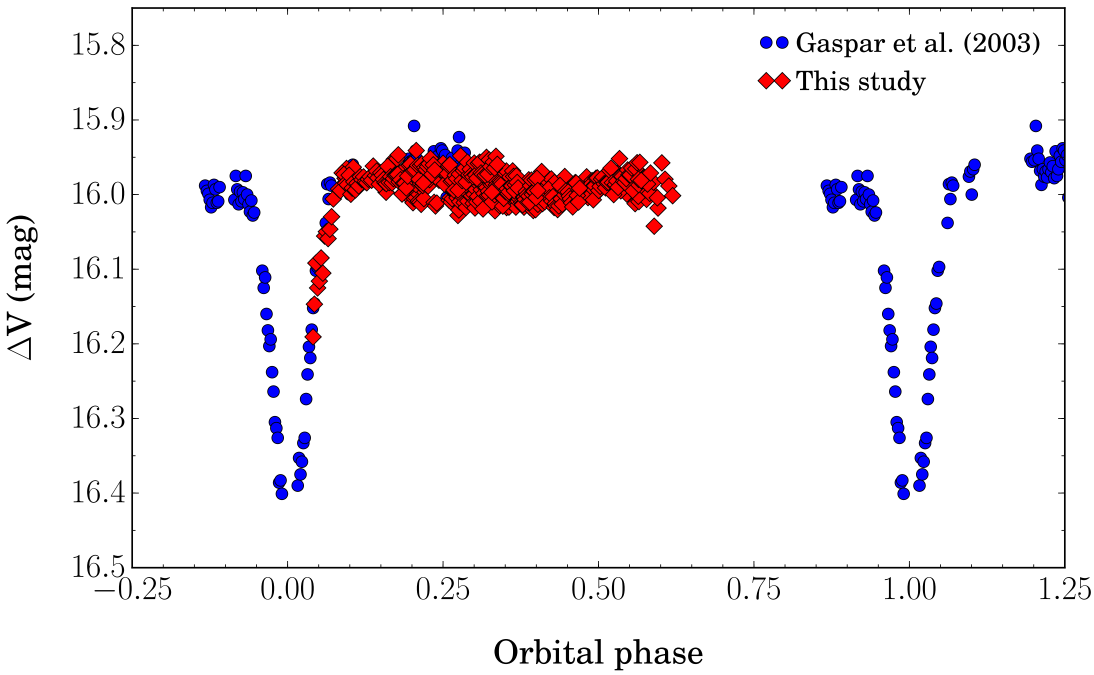

Figure 6.19: Differential V observations of V549 Aur folded according to the new ephemeris. Blue circles show the data observed by Gáspár et al. (2003) and red diamond points show the data observed by us.

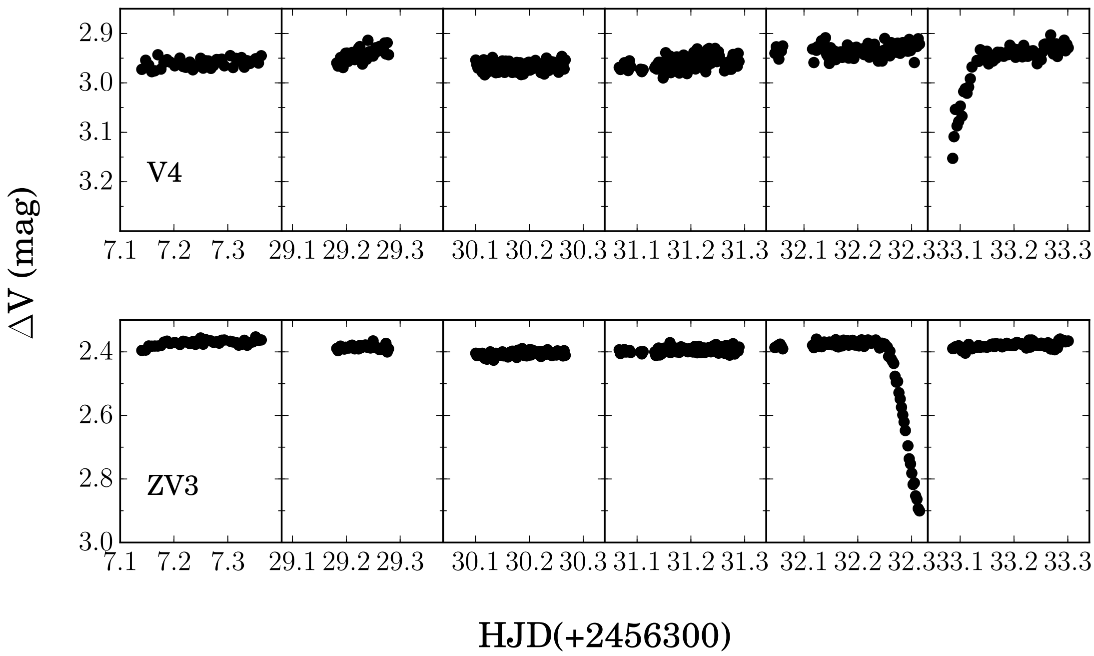

Figure 6.20: Individual V light curve of eclipsing binaries V4 and ZV3. The full primary and secondary minima for these two Algol-type eclipsing binaries could not be detected in our observations.

6.5.3 V551 Aur

V551 Aur is a detached eclipsing binary with a pulsating component and an orbital period of 1.17320(3) d which was first discovered by Gáspár et al. (2003). The system shows steady δ Scuti-like oscillations outside eclipse. We aim to derive accurate orbital and pulsation periods of the system and to verify the possible connection between the pulsation and the orbital motion caused by a mechanism of resonance (Willems and Aerts, 2002). In this study, we obtained the new value of 1.1731744 d for the orbital period. The light curve was analyzed using the Wilson Devinney technique in order to obtain a new set of the system's parameters. According to our analysis, the solution shows that V551 Aur is a detached binary system with q = 0.769 and i = 73.01 degrees. From the period analysis of the residuals, we confirm the presence of pulsations with a main frequency of 7.71315 c/d having a semi amplitude of 18.95 mmag. The analyses and new results of the eclipsing binary system V551 Aur are discussed in the next chapter.

Table 6.4: Summary of all variable stars in the field of open cluster NGC 2126

ID	Name	UCAC4 Catalog	RA(J2000)	Dec.(J2000)	V	B-V	P_{orb}(d)	P_{pul}(d)	Epoch	Type
V1	V546 Aur	700-043101	06:01:44.14	+49:56:30.40	13.91	0.55	-	0.819806	2453091.564448	γ Dor
V2	V547 Aur	700-043129	06:01:57.42	+49:58:54.85	14.41	0.55	-	0.883314	2453089.978222	γ Dor
V3	V548 Aur	700-043145	06:02:05.28	+49:49:11.27	15.31	0.56	-	0.062996	2453088.716211	δ Scuti
V4	V549 Aur	700-043177	06:02:21.33	+49:52:37.10	16.02	0.96	1.096637	-	2452308.383560	EA
V5	V550 Aur	700-043190	06:02:26.43	+49:51:56.54	13.16	0.55	-	0.087389	2456333.154568	δ Scuti
V6	V551 Aur	700-043241	06:02:38.04	+49:53:02.48	14.57	0.72	1.173175	0.129649	2456331.210182 or 2452640.596710	EA+ δ Scuti
ZV1	-	700-043212	06:02:33.06	+49:52:47.64	13.39	0.57	-	0.081620	2456333.138119	δ Scuti
ZV2	-	700-043178	06:02:21.74	+49:52:23.49	13.66	0.54	-	0.067353	2456329.259578	Hybrid
ZV3	-	700-043174	06:02:20.44	+49:48:23.50	15.66	0.78	-	-	-	EA
N1	-	700-043245	06:02:38.74	+49:52:45.11	13.34	0.54	-	0.073543	2456331.201196	δ Scuti
N2	-	700-043196	06:02:27.46	+49:50:42.73	13.73	0.54	-	0.068717	2456333.261286	δ Scuti

Table 6.5: Review variable stars in open clusters. N is the number of variables found in each cluster. Ref. 1) Zwintz and Weiss 2006, 2) Rose and Hintz 2007, 3) Zhang et al. 2012, 4) Moździerski et al. 2014, 5) Rose and Hintz 2007, 6) Barden et al. 2004 , 7) van Cauteren et al. 2005, 8) Arentoft et al. 2004, 9) Kang et al. 2007, 10) Kim et al. 2001b, 11) Balona and Laney 1996, 12) Kim et al. 2001a, 13) Arentoft et al. 2007, 14) Zerbi et al. 1998, 15) Choo et al. 2003, 16) Mowlavi et al. 2013, 17) Arentoft et al. 2001, 18) Zwintz et al. 2005, 19) Martín et al. 2004, 20) Ciechanowska et al. 2007, 21) Rose and Hintz 2007, 22) Pigulski et al. 2000, 23) Joshi et al. 2012, 24) Delgado et al. 1984, 25) Hintz and Rose 2005, 26) Peña et al. 2001, 27) Choi et al. 1999, 28) Mochejska and Kaluzny 1999. Galactic coordinates, Distance, E(B-V), and log(age) were extracted from WEBDA database.

Open Cluster	l	b	Distance (pc)	E(B-V) (mag)	log (age)	N	Ref
IC 4996	75.35	1.31	1732	0.673	6.948	2	1
NGC 225	122.01	-1.08	657	0.274	8.114	21	2
NGC 457	126.64	-4.38	2429	0.472	7.324	79	3,4
NGC 559	127.19	0.75	1258	0.790	7.748	18	5
NGC 752	137.13	-23.25	457	0.034	9.050	2	6
NGC 1664	161.68	-0.45	1199	0.254	8.465	2	7
NGC 1817	186.16	-13.10	1972	0.334	8.612	14	8
NGC 2099	177.63	3.09	1383	0.302	8.540	17	9
NGC 2301	212.56	0.28	872	0.028	8.216	8	10
NGC 2362	238.18	-5.55	1389	0.095	6.914	6	11
NGC 2506	230.56	9.94	3460	0.081	9.045	28	12,13
NGC 2516	273.82	-15.86	409	0.101	8.052	2	14
NGC 2539	233.71	11.11	1363	0.082	8.570	7	15
NGC 3766	294.12	-0.03	1745	0.175	7.160	107	16
NGC 6231	343.46	1.18	1243	0.439	6.843	17	17
NGC 6383	355.69	0.04	985	0.298	6.962	6	18
NGC 6530	6.08	-1.33	1330	0.333	6.867	6	1
NGC 6633	36.01	8.33	376	0.182	8.629	7	19
NGC 6755	38.60	-1.69	1421	0.826	7.719	71	20
NGC 6811	79.21	12.02	1215	0.160	8.799	9	7,21
NGC 6823	59.40	-0.14	1893	0.845	6.820	10	22
NGC 6866	79.56	6.84	1450	0.169	8.576	28	23
NGC 6871	72.64	2.05	1574	0.443	6.958	2	24
NGC 6882	65.78	-3.85	-	-	-	15	25
NGC 6910	78.68	2.01	1139	0.971	7.127	2	26
NGC 6913	76.90	0.59	1148	0.744	7.111	2	26
NGC 6940	69.86	-7.15	770	0.214	8.858	16	21
NGC 7142	105.35	9.48	1686	0.397	9.276	20	21
NGC 7160	104.01	6.46	789	0.375	7.278	16	21
NGC 7209	95.50	-7.34	1168	0.168	8.617	3	7
NGC 7654	112.82	0.43	1421	0.646	7.764	4	27
NGC 7789	115.53	-5.39	2337	0.217	9.235	45	28