Turk J Phys
32 (2008) , 5 – 12.

Multiple Period Search for K, M and C Type Semiregular Variables in TÜBİTAK National Observatory

Cahit YEŞİLYAPRAK[1], Timur ŞAHİN[2], Ahmet İSKENDER[3]
[1] *Atatürk University, Art & Science Faculty, Physics Department, 25240, Campus, Erzurum-TURKEY*
e-mail: cahity@atauni.edu.tr
[2] *Armagh Observatory, College Hill, Armagh, Northern-IRELAND*
e-mail: tsa@arm.ac.uk
[3] *İnönü University, Art & Science Faculty, Physics Department, Malatya-TURKEY*
e-mail: aiskender@inonu.edu.tr

Received 06.07.2007

Abstract

In this study, periods obtained from long-term multi-bands (Johnson V and R filters) photometric observations of some K, M and C spectral type semiregular (SR) variables obtained with the T40 telescope (40 cm) and SSP5A photometer at TÜBİTAK National Observatory (TNO) between 1998 and 2005 were examined. We have found that some of these SR variables have multiple (long and short) periods as appeared mostly from Hipparcos observations; three variables are, for the first time, observed to have a period. The light curves, the variation amplitude in R band and the maximum light Epoch(s) of SR variables were also given. Besides, some difficulties encountered in the long-term observations were also discussed briefly.

Key Words: stars: variable stars: late-type stars: photometry, stars: period.

1. Introduction

In the General Catalog of Variable Stars (GCVS4) [1], semiregular (SR) variable stars are defined as intermediate (F, G, K) or late spectral type (M, C, S) giants or supergiants. SR variables indicate the noticeable light changes but sometimes these variations were interrupted by different irregularities or even stable phase. So, the shapes of their light curves are often different and variable. The periods known classically change from 20 to 2000 d or more for SR variables in GCVS4 [1]. The visual (V) light amplitude is, as a rule, less than 2.5 mag. SR variables are classified as four subtypes: SRa, SRb, SRc, SRd. GCVS4 [1] defines that SRa variables are late type (M, C, S) giants and show persistent periodicity but many SRa variables differ from Mira type variables only by their smaller light amplitude which is less than 2.5 mag in V band. According to Kerschbaum and Hron [2, 3], SRa variables do not form a distinct class, but probably a mixture of SRb variables and Mira variables. SRb variables are late type giants (M, C, S) with poorly expressed periodicity and sometimes show irregular variations, or even light constancy [1] and many of SRb variables also show multiple periodicity [4, 5]. SRc and SRd variables do not show more periodic, stable and noticeable variations than SRa and SRb variables. SRc and SRd variables were not observed in this study because of their different variation properties and the difficulties of searching period(s).

In order to search or determine a period or multiple periods (multi-periods) in SR and Mira type variables, the long-term (about 8–10 years; e.g. see [6]), continuous and regular observations are necessary. SR variables with multi-periods are related to pulsation mode changes of SR variables [5, 7, 8], but it is not so clear whether these multi-periods are the result of mode switching between Mira-like and SR-like pulsation modes [9], or an indication of an evolutionary change from SR stage to Mira stage [10, 11]. In fact, it still is not clear in which mode SR variables are pulsating exactly. For example, according to Koen & Laney [12], SR variables with short periods appear to be pulsating in higher modes. So, the period search for SR variables is an important data source for the pulsation mode studies summarized above.

The aim of this study is to search the period/multi-periods of SR variables obtained from photometric observations conducted long-term at TNO. The period/multi-period data obtained from our observations can be used to determine pulsation modes by means of Period-Radius (P-R) relations in different pulsation studies mentioned briefly above, and the Period-Luminosity relations (P-L) of SR variables; for example, the studies of Yeşilyaprak and Aslan [13] and Yeşilyaprak et al [14].

2. The Stars: Observations and Reductions

The SR variables examined in this study were selected from The Hipparcos Catalogue [15] and among stars known as having a period or multi-periods. Because the short period or multi-periods were appeared mostly from Hipparcos observations [15], the spectral types of selected SR variables are K, M and C.

All SR variables in this study were observed in the long-term with the T40 Cassegrain telescope and the OPTEC SSP-5A photoelectric photometer (Hamamatsu 4457 PMT) at the TÜBİTAK National Observatory (TNO), between 1998 and 2005. Most observations were conducted though Johnson V and R filters [16]. The observation nights were planned consecutive 3–5 days in an observation time interval of 15–20 days. In a typical observation night, 20–25 SR variables could be observed with V and R bands. Preliminary results about the period search of SR variables were first presented via an oral presentation at the 2006 National Astronomy Congress [17]; there, the probable periods determined from our observations in TNO were presented. In the present study, the most probable periods are determined and presented.

In the long-term observations of SR variables, we encountered difficulties, such as unexpected atmospheric conditions, insufficient observation time and observer, taking irregular, inadequate or infrequent observation data, etc. Therefore, further long-term, continuous, regular and collective observations are needed for the variables under study.

The reductions of the photometric observations were made in the usual way by means of the photometric reduction package "Rasat" [18, 19] and the periods were determined via the "Period04" software package [20].

3. Observed SR Variables and Period(s)

The SR variables which have long-term observations and sufficient data points for determination of their periods are listed in Table 1. The periods given in Table 1 were taken from The Hipparcos Catalogue [15], SIMBAD Database and the studies of Koen & Laney [12, 21].

In Table 2 is listed the periods P of SR variables obtained from our observations at TNO, together with the number of observations N, the magnitude range in the R band (ΔR) and the Epochs of maximum lights of observed SR variables. Four SR variables in Table 2 (V Crb, V897 Her, HP Peg, V338 Peg) have multi-periods determined from our long term observations at TNO. The differential light curves in R with the best period fits and the power spectrums of some of selected SR variables are shown in Figures 1–7.

4. Results and Conclusions

The periods and the maximum light Epochs of some K, M and C type SR variables were found from our long-term observations with T40 telescope and accompanying photometer at TNO, between 1998 and 2005. Four SR variables examined in this study have multi-periods and for the first time periods are found for three of them.

Table 1. The observed SR variables.

Name	V (mag)	Spectral Type	Variable Type	Comp. Star	ΔT +2400000	Period (days)
AH Ari	8.3	K5	SR	HD 15867	52172 – 53264	4.2
RY Cam	8.4	M3	SRb	SAO 13168	52475 – 53652	134.2
VZ Cam	4.9	M4	SR	HD 52029	51513 – 53761	23.7
AR Cep	7.4	M4	SRb	HD 216720	52060 – 53624	?
V Crb	9.3	C	SR	HD 141566	50994 – 53569	358.0
V640 Her	6.2	M4	SR	HD 157822	52060 – 53624	29.4
V897 Her	6.9	K0	SR	SAO 121644	51733 – 53569	15.2
V992 Her	8.9	K2	SR	SAO 103731	52500 – 53624	?
V2361 Oph	8.8	M4	SR	HD 153402	52427 – 53572	3.5
HP Peg	8.9	C	SR	HD 209694	50575 – 53624	?
V338 Peg	7.4	M	SR	HD 217557	52474 – 52944	6.6

Table 2. The Periods of SR variables determined from our observations at TNO.

Name	N	ΔR (mag)	$T_{\max}$ +2400000	Period(s) (days)
AH Ari	23	0.15	52605	547
RY Cam	21	1.15	52487	136
VZ Cam	62	0.09	51646	27
AR Cep	27	0.58	52154	118
V Crb	29	2.10	51651, 47614	339, 3923
V640 Her	18	0.12	52090	227
V897 Her	24	0.13	52794, 52753	15, 58
V992 Her	34	0.20	52804	32
V2361 Oph	29	0.15	52539	132
HP Peg	49	0.03	51501, 51267	350, 573
V338 Peg	37	0.22	52468, 52094	21, 396

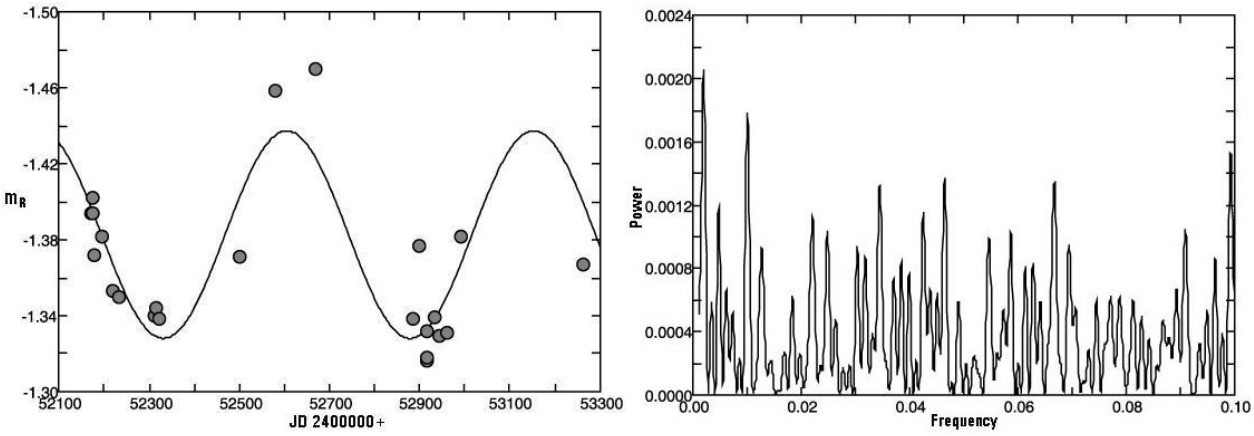

Figure 1. Light curve with period fit (547 days) and the power spectrum of AH Ari.

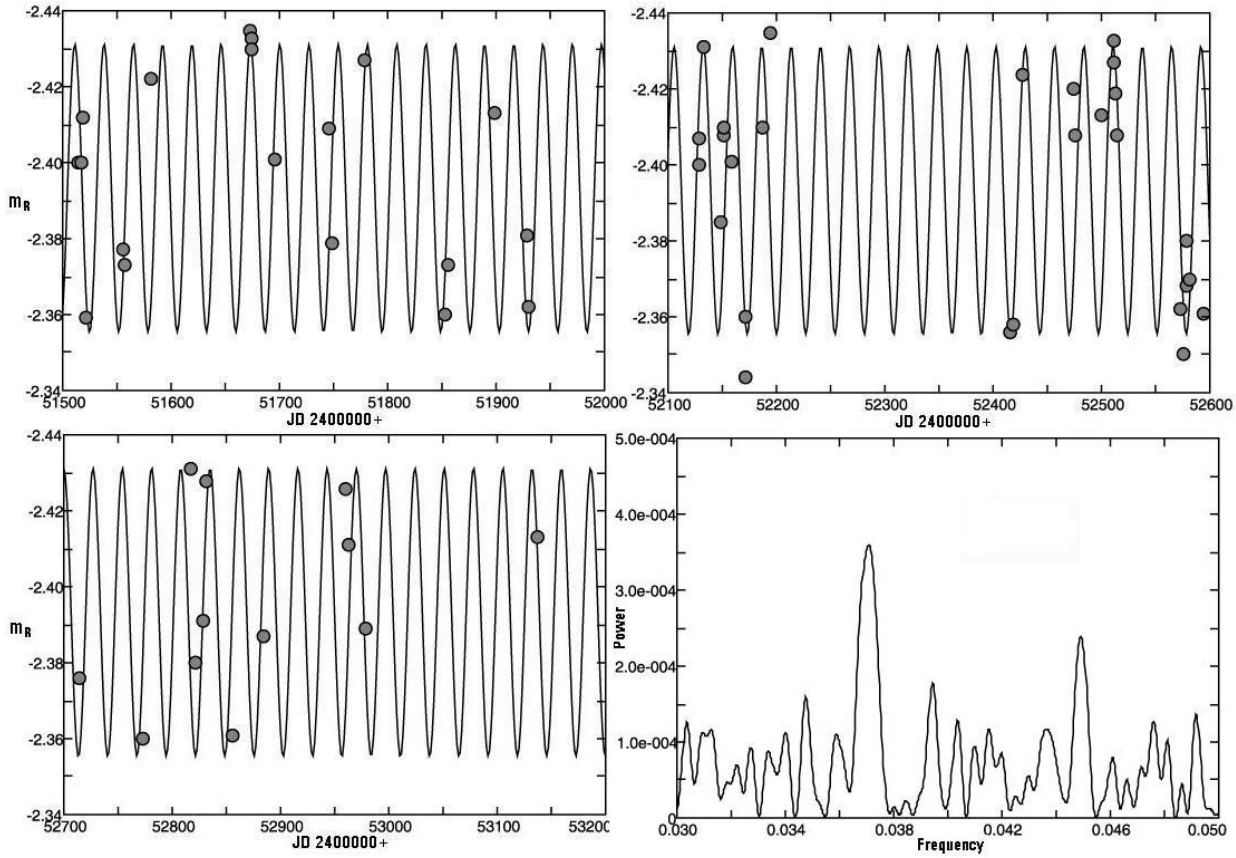

Figure 2. Light curve with period fit (27 days) and the power spectrum of VZ Cam.

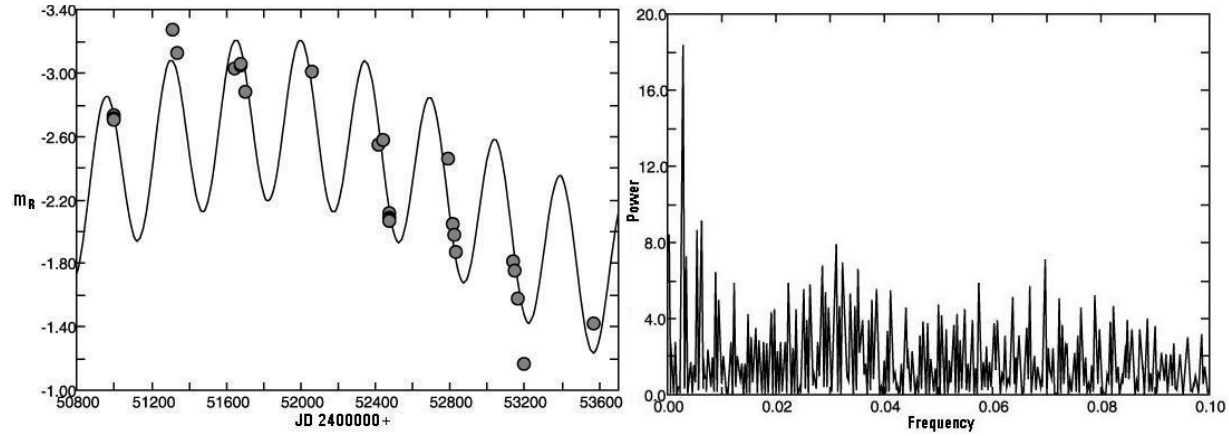

Figure 3. Light curve with 2 periods fit (339 and 3923 days) and the power spectrum of V Crb.

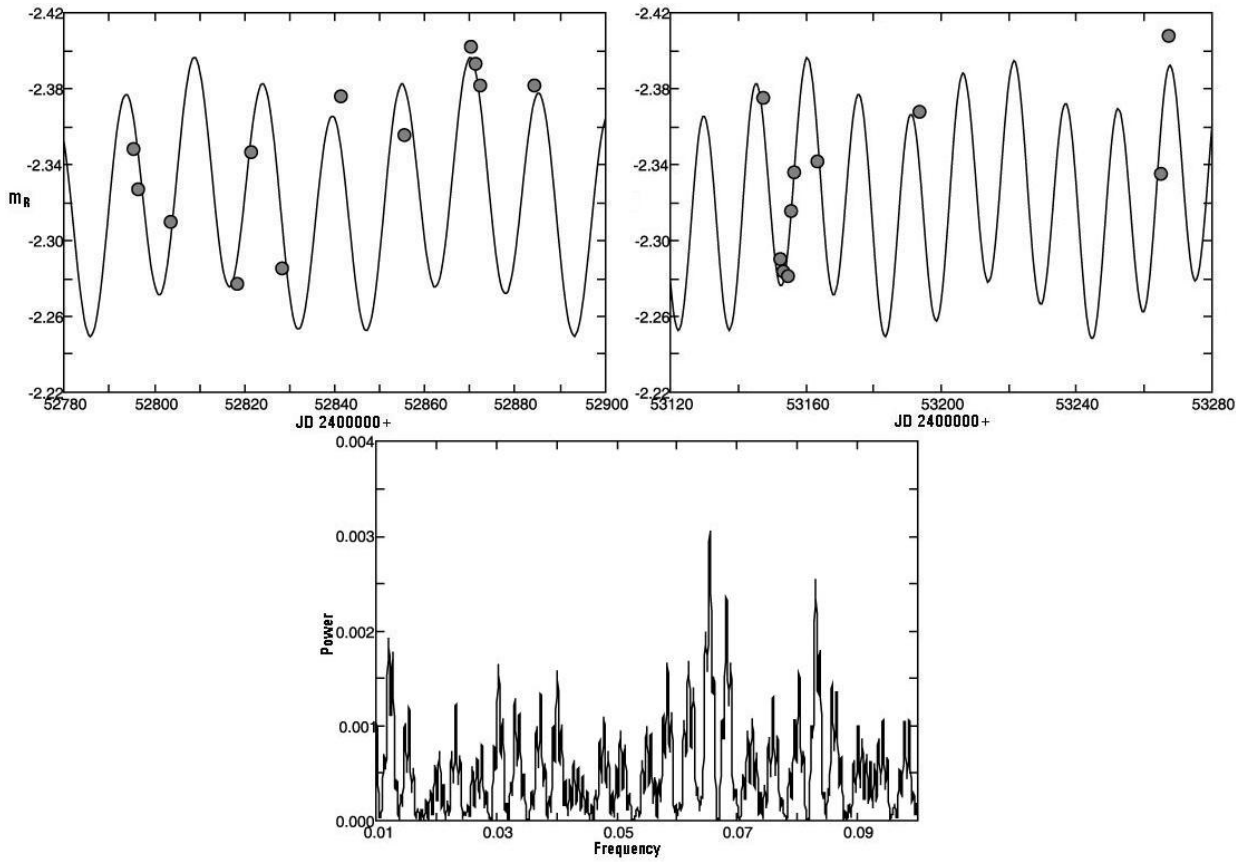

Figure 4. The light curve with 2 periods fit (15 and 58 days) and the power spectrum of V897 Her.

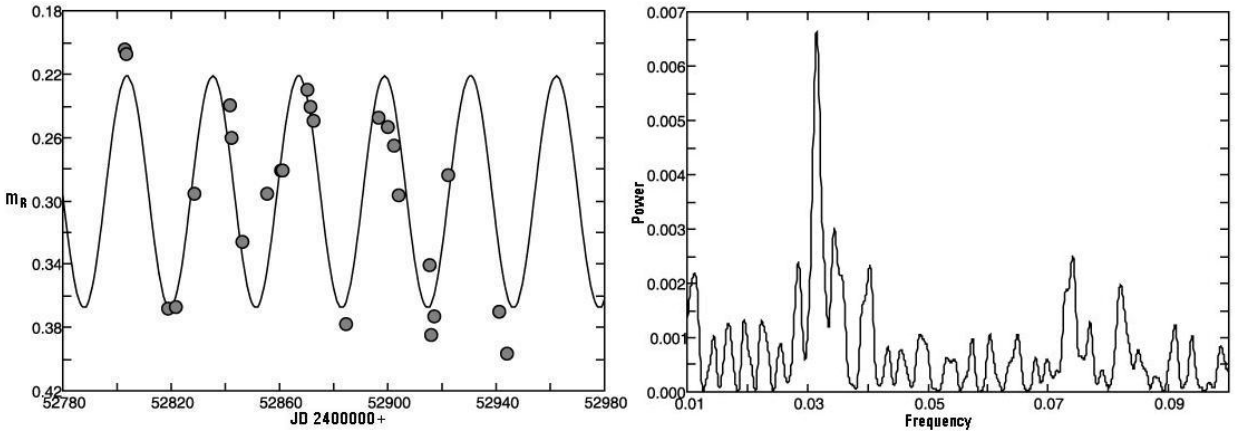

Figure 5. Light curve with period fit (32 days) and the power spectrum of V992 Her.

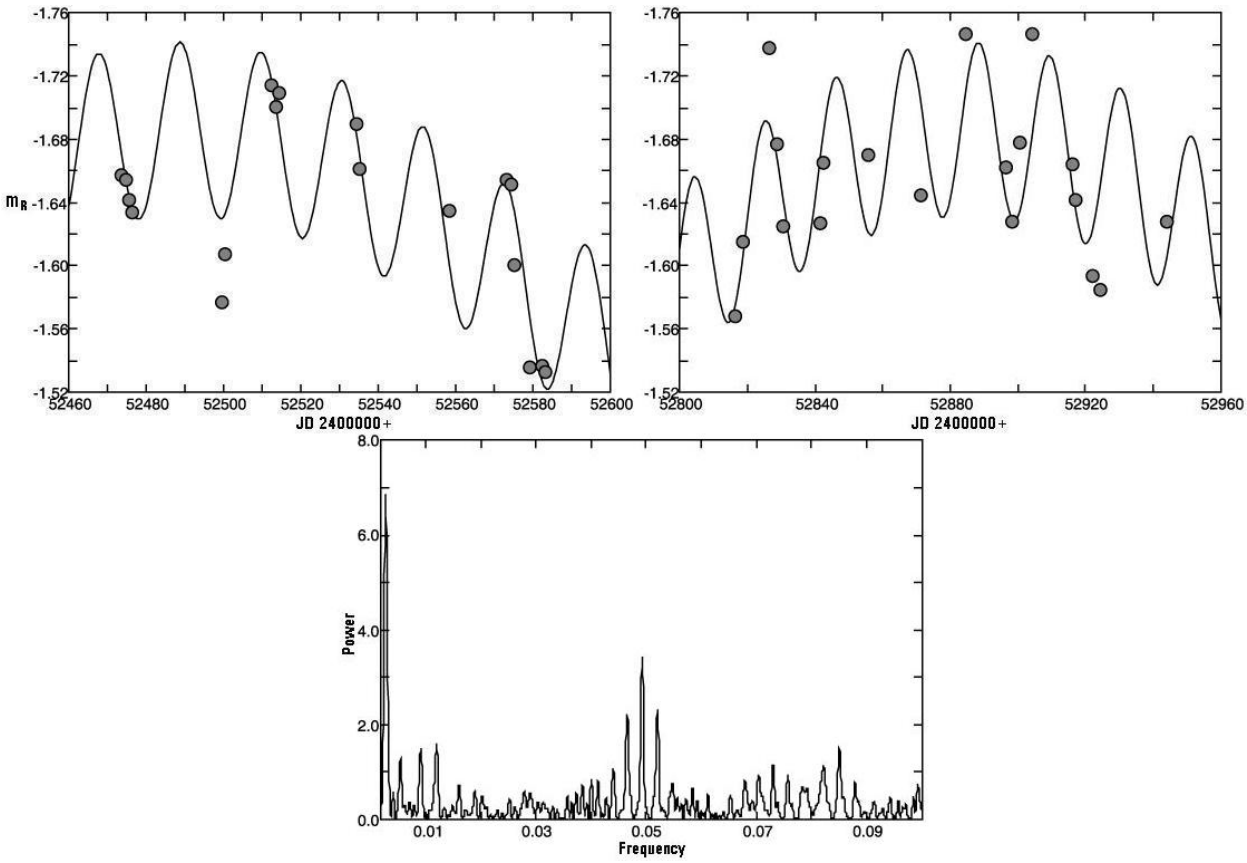

Figure 6. Light curve with 2 periods fit (21 and 396 days) and the power spectrum of V338 Peg.

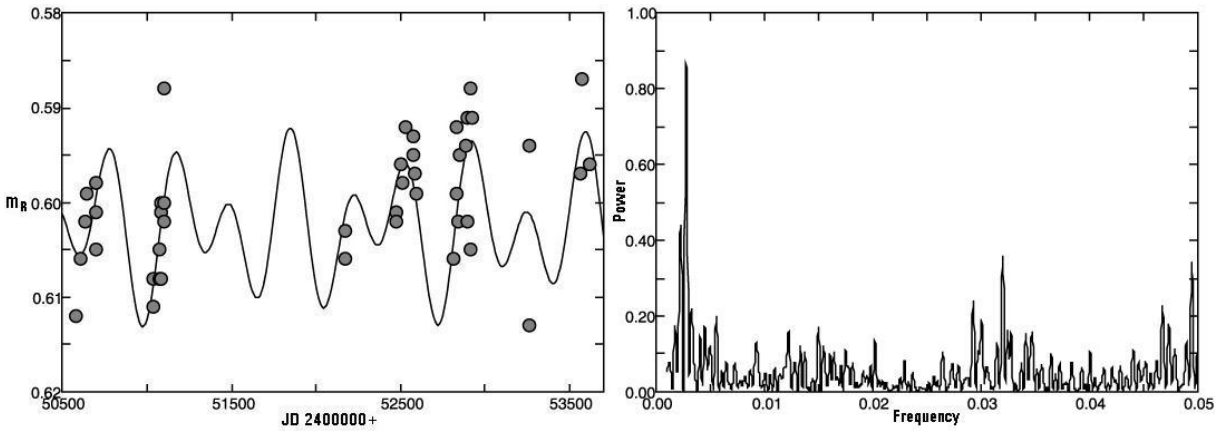

Figure 7. Light curve with 2 periods fit (350 and 573 days) and the power spectrum of HP Peg.

There are some difficulties encountered in these type long-term observations and SR variables, arising from atmospheric conditions, inadequate observation time, data and observer, semi-regular natures of variations etc. Thus needed is long-term, continuous, regular and collective observations for such observations especially related to SR variables. The most appropriate telescopes for these observations are generally robotic telescopes observing regularly and observer independent telescope system. SR variable observations have been carried on the RotseIIId telescope in TNO since the second part of year 2005.

Acknowledgements

The authors acknowledge the use of the SIMBAD Database, operated by CDS, Strasbourg. We would like to thank the TÜBİTAK National Observatory (TNO) for the observations, equipment support and library facility. Also, we are grateful to Prof. Dr. Zeki Aslan especially for his guidance and helpful comments about the long term observations of SR variables.

References

[1] P. N. Kholopov, N. N. Samus, M. S. Frolov, et al., *General Catalogues of Variable Stars (GCVS4)*, (4^{th}. Edition, Nauka Publishing House, Moscow, 1988).

[2] F. Kerschbaum and J. Hron, *A&A*, **263**, (1992), 97.

[3] F. Kerschbaum and J. Hron, *A&AS*, **106**, (1994), 397.

[4] J. A. Mattei, G. Foster, L. A. Hurwitz, et al., *Classification of Red Variables*, ed. B. Battrick, The Proceedings of The ESA (European Space Agency) Symposium, Hipparcos-Venice '97, (ESA SP-402, 1998), pp. 269-274.

[5] L. L. Kiss, K. Szatmáry, J. R. R. Cadmus, et al., *A&A*, **346**, (1999), 542.

[6] J. R. Percy, A. Desjardins, L. Yu, et al., *PASP*, **108**, (1996), 139.

[7] M. W. Fox and P. R. Wood, *ApJ*, **259**, (1982), 198.

[8] P. R. Wood and K. M. Sebo, *MNRAS*, **282**, (1996), 958.

[9] G. R. Knapp, D. Pourbaix, I. Platais, et al., *A&A*, **403**, (2003), 993.

[10] T. R. Bedding and A. A. Zijlstra, *ApJ*, **506**, (1998), L47.

[11] P. R. Wood, *PASA*, **17**, (2000), 18.

[12] C. Koen and D. Laney, *MNRAS*, **311**, (2000), 636.

[13] C. Yeşilyaprak and Z. Aslan, *MNRAS*, **355**, (2004), 601.

[14] C. Yeşilyaprak, Ü. Kızıloğlu, N. Kızıloğlu, *The Post-Doctoral Project in Middle East Technical University - Physics Department and also The Post-Doctoral Scholarship supported by TÜBİTAK*, "The Determination of Pulsation Properties of SR Variables and Their Evolution", (2007).

[15] ESA (European Space Agency), *The Hipparcos Catalogue (HIP)*, (1997), ESA SP-1200.

[16] H. L. Johnson, *ApJ*, **141**, (1965), 923.

[17] C. Yeşilyaprak, T. Şahin, A. İskender, *SR Tipi KırmızıYıldızların Uzun Dönemli Gözlemleri ve Periyot Analizleri - The Long Term Observations of SR Type Red Stars and The Period Analysis*, 15. Ulusal Astronomi Kongresi - 15. National Astronomy Congress (28.08 - 01.09.2006), (2007), İstanbul Kültür Üniversitesi, ed. H. Gülseçen, F. Limboz, A. F. Teker, İstanbul Kültür Üniv. Yayınları, 60, II, 905 - 913, İstanbul.

[18] H. Ay, *Y. Lisans Tezi - MSc Thesis*, "TÜBİTAK Ulusal Gözlemevi'nde gözlem bilgilerinin veri tabanına aktarılmasıve gözlem sonuçlarının değerlendirilmesi", Akdeniz University, Science Institute (1999), p.66, Antalya.

[19] C. Yeşilyaprak, M. Parmaksızoğlu, K. Uluç, et al., *VZ Cam'ın ışık ölçümü - Photometry of VZ Cam*, ed. C. İbanoğlu, 12. Ulusal Astronomi Kongresi - 12. National Astronomy Congress (4-8.09.2000), (2001), Ege Üniversitesi Yayınları, pp. 255-263, İzmir.

[20] P. Lenz and M. Breger, *CoAst*, **146**, (2005), 53.

[21] C. Koen and D. Laney, *MNRAS*, **331**, (2002), 45.