New and confirmed variables in the field of Eta Carinae. Discovery of new massive O-type eclipsing binaries

Sebastián A. Otero – CEA – Grupo Wezen 1 88 - varsao@fullzero.com.ar

Abstract:
A search for massive eclipsing binaries in the eta Carinae area resulted in the discovery or confirmation of eighteen variable stars. Six of them are in fact eclipsing binaries and three are O-type systems.

Methodology

The eta Carinae nebula and its surroundings are full of massive early type stars so the ASAS-3 database (Pojmanski, 2002) was searched with the aim of finding new massive eclipsing binary systems. The sky area between 10h 41m and 10h 48m in RA and -59º 10' and -60º 10' in DEC (J2000.0) was investigated. The lightcurves of all stars brighter than 13th magnitude with more than 100 observations in the database that showed mean error figures higher than normal for a given magnitude were visually inspected to detect variability and to discard light contamination problems.
Magnitudes should be taken as approximate values since in this crowded field results are generally the combination of the light from two or more stars.
Three O-type eclipsing binaries have been found (two of them unknown) and several other variables of different types have been discovered or confirmed.
Fig. 19 is a finding chart with all variables plotted

Results

Table 1 gives positions and cross-identifications for all the variables. The first column gives the ASAS identifier (N = not in the ASAS catalogue). The following columns give another identifier; a GCVS name if available and the star's position according to the UCAC2 catalogue (Zacharias et al., 2004).

Table 1 – Positions and cross-identifications for the 18 stars studied.

Star Name					UCAC2 position (J2000.0)
#	ASAS ID		Other ID	GCVS ID	
1	104331-5929.4	N	HD 303312		10 43 30.84 -59 29 23.9
2	104400-5952.5	N	HD 093130	NSV 18497	10 44 00.37 -59 52 27.5
3	104513-5944.8	N	CPD-59 2635		10 45 12.71 -59 44 46.2
4	104536-5948.4		GSC 8626 1030	NSV 18518	10 45 36.32 -59 48 23.2
5	104639-5923.8	N	HD 303302		10 46 38.85 -59 23 46.3
6	104728-5937.8	N	HD 303408		10 47 27.83 -59 37 46.7
7	104059-5923.1		GSC 8626 2521	FU Car	10 41 00.28 -59 23 12.6
8	104130-5956.9		HD 305440		10 41 29.95 -59 56 57.6
9	104159-5949.9		HD 092853		10 41 58.41 -59 49 57.4
10	104205-5933.4		HD 092876		10 42 05.57 -59 33 26.7
11	104233-5935.5	N	HD 092937		10 42 32.15 -59 35 30.3
12	104327-6005.9	N	HD 093056		10 43 27.40 -60 05 54.8
13	104334-5918.5		GSC 8626 1999		10 43 33.77 -59 18 28.3
14	104340-6010.1	N	CGCS 2842	NSV 18486	10 43 39.58 -60 10 22.1
15	104440-6003.6		GSC 8957 2655		10 44 40.50 -60 03 33.3
16	104457-5956.1	N	HD 093281		10 44 57.34 -59 56 06.4
17	104730-5911.7		HD 303389		10 47 30.47 -59 11 37.8
18	104800-5941.4		GSC 8626 1905		10 48 00.40 -59 41 21.3

Table 2 lists the six eclipsing binaries found. The first column gives the star's number in this paper. The other columns give the brightness range of the variable with the ASAS-V magnitudes for maximum, primary minimum and secondary minimum; the variability class; the period; the epoch of minimum light derived from the complete dataset; the spectral type and the spectral type source.

Table 2 – Elements and data for the eclipsing binaries studied

#	Magnitude range (V)			Type	Period (days)	Epoch (HJD)	Spectral type	Source for sp. type
	Max	Min I	Min II					
1	9.95	10.16	10.05	EA/DM	9.4109	2452979.820	B0V(n)	Skiff, 2005
2	8.07	8.28	8.2:	EA	23.944	2453131.619	O6III(f)	C.-González et al., 1974
3	9.27	9.78:	9.7:	EA/DM	2.29995	2452652.800	O8V+O9.5V	A. Colombo et al., 2001
4	12.09	12.7	12.45	EA/KE	1.41355	2453490.609	O4V	Kholopov et al., 2005
5	10.76	11.03	10.91	EA	2.95697	2451920.833	B2-B3	Loden et al., 1976
6	11.20	11.58	11.30	EA	3.10746	2452662.788	A	Nesterov et al., 1995

Notes on individual stars for Table 2:

#1 – HD 303312 = Extremely eccentric system (Min II at phase 0.16). Light contamination from nearby stars.

#2 – NSV 18497 = Eccentric system (Min II at phase 0.65). Classified as ACYG in the NSV catalogue (Kholopov et al., 2005). Visual 12th mag. companion at 11".9 (Worley et al., 1997). Spectroscopic period (14.016 d.) in Levato et al. (1990) is wrong. No observations at mideclipse II. ASAS magnitudes were corrected according to V observations from the ground (Mermilliod et al., 1997).

#3 – CPD-59 2635 = In Trumpler 16. ASAS magnitudes are for a blend of 3 bright stars: CPD-59 2635 = 9.3V; CPD-59 2633 = 9.6V; CPD-59 2636 = 9.3V and several other fainter stars. It results in V= 8.1 at maximum. The magnitudes given have been corrected for light contamination but should be taken as approximate. The eclipsing binary is identified by its spectroscopic period in Albacete Colombo et al. (2001), who found no light variations and proposed an inclination of 56 degrees.

#4 – NSV 18518 = Classified as ESD/ED (semidetached or detached binary) in the ASAS catalogue with a period of 1.41355 d.

#5 – HD 303302 = Wrongly identified as the 12th mag. star ASAS 104639-5924.2 in the ASAS catalogue. The eclipsing binary is ASAS 104639-5923.8. Classified as ED (detached binary) with a period of 2.957 d. Slightly eccentric system.

#6 – HD 303408 = Eccentric system (Min II at phase 0.44).

Since the fundamental parameters of O-type eclipsing binaries are important for evolutionary theories on massive stars, the O-type systems presented in this paper are being followed photometrically by members of the Austral Variable Star Observer Network (AVSON) in order to get more data on their nature.

Table 3 lists the other types of variable stars found. Columns are the same as in Table 2.

Table 3 – Elements and data for the rest of the variables studied

#	Magnitude range (V)		Type	Period (days)	Epoch (HJD)	Spectral type	Source for sp. type
	Max	Min					
7	11.1:	<14.0	M	416.5	2453474.72	C5e	Buscombe, 1999
8	9.69	9.82	ACV	3.08133	2453091.765	B8	Nesterov et al., 1995
9	9.48	9.66	GCAS	------	--------	B9	Houk & Cowley, 1975
10	8.50	8.98	SR	52.95	2452931.87	M4/M5III:	Ochsenbein, 1980
11	8.84	9.01	GCAS	------	--------	B2/3II	Houk & Cowley, 1975
12	8.86	9.03	BCEP	0.451686	2452255.763	B1V	Skiff, 2005
13	11.6	12.4	SR	57.1	2453423.0	M	Loden et al., 1976
14	----	(0.2)	L:	------	2452729	C	Skiff, 2005
15	9.23	9.77	SRa:	106	2453394		
16	7.7	7.9	SRc:	99.8:	2452984	M1Iab+B	Ochsenbein, 1980
17	10.26	10.39	ACV	3.1450	2452929.874	B8V	Buscombe, 1998
18	10.42	10.86	SR	22.25	2451885.70	M5-M7	Loden et al., 1976

Notes on individual stars for Table 3:

#7 – FU Car = Classified as M:-type in the GCVS (Kholopov et al., 2005) with a period of 365: d. Classified as MISC with a period of 433 d. in the ASAS catalogue. Light contaminated by the nearby 11.3 mag. Star GSC 8626 1299. Combined brightness measured V= 10.46 – 11.36. Magnitudes given in the table have been corrected for light contamination but should be taken as uncertain.

#8 – HD 305440 = Measured together with GSC 8626 1914. Classified as ESD/DCEP-FO/EC with a period of 6.1630 d. in the ASAS catalogue.

#9 – HD 92853 = Classified as MISC with a period of 1007 d. in the ASAS catalogue. Slow outburst. Visual 11th mag. companion at 0".4 (Dommanget et al., 2002).

#10 – HD 92876 = Classified as MISC with a period of 105.9 d. in the ASAS catalogue.

#11 – HD 92937 = Short small amplitude outbursts.

#12 – HD 93056 = Amplitude changes. Probably multiperiodic.

#13 – GSC 8626 1999 = Classified as MISC with a period of 366 d. in the ASAS catalogue.

#14 – NSV 18486 = Results are a blend of this carbon star and the 11th magnitude B-type star GSC 8957 1385. No magnitude or amplitude can be extracted from ASAS data alone. 2MASS J-K is 2.4. The visual magnitude is listed between 13 and 14.5 in the literature. UCAC 2 magnitude is 12.51.

#15 – GSC 8957 2655 = Classified as EC (contact binary) with a period of 212 d. in the ASAS catalogue. 2MASS colors are those of a red star (J-K 1.16). A large amplitude ellipsoidal variable is not excluded.

#16 – HD 93281 = VV Cep-type system. ASAS V values were shifted down 0.15 mag. to correct for light contamination from GSC 8626 1762 and GSC 8626 2497. Amplitude might be larger.

#17 – HD 303389 = Classified as DCEP-FU with a period of 3.1451 d. in the ASAS catalogue.

#18 – GSC 8626 1905 = Classified as MISC with a period of 22.36 d. in the ASAS catalogue.

Figures 1 to 18 show the lightcurves of all the stars studied in this paper.

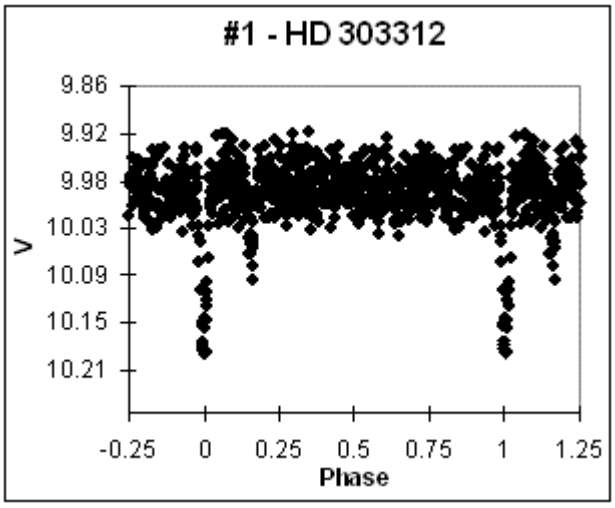

Fig. 1 – Lightcurve of HD 303312

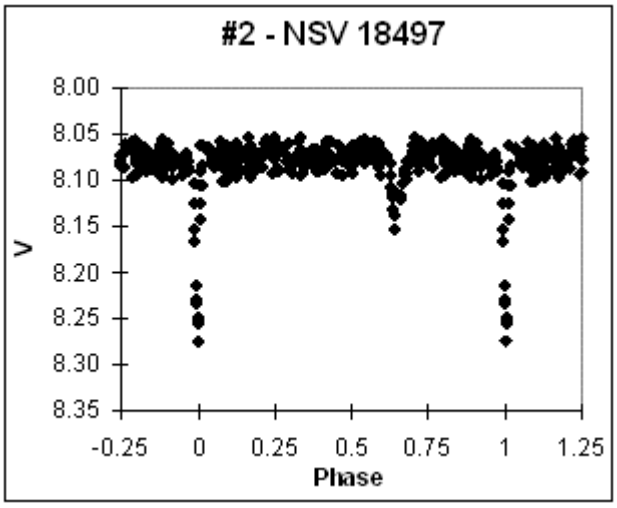

Fig.2 – Lightcurve of NSV 18497

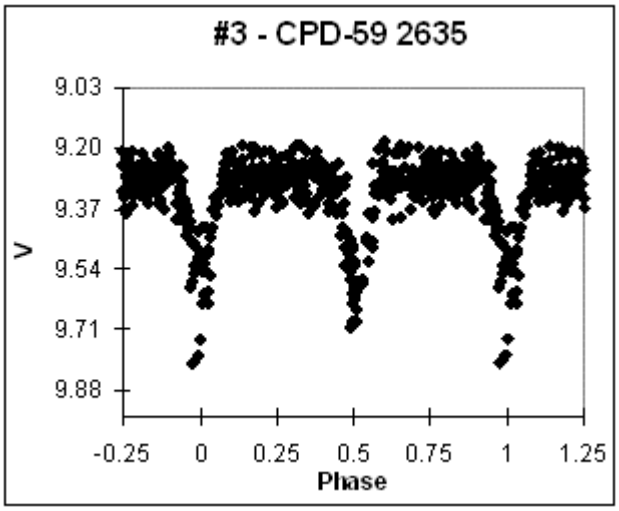

Fig.3 – Lightcurve of CPD-59 2635

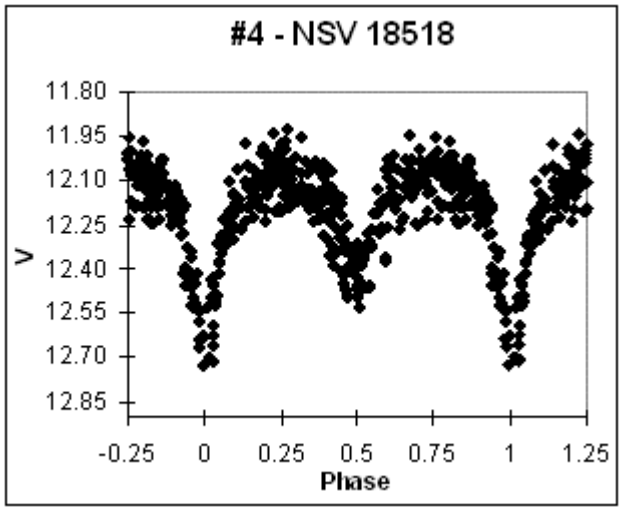

Fig. 4 – Lightcurve of NSV 18518

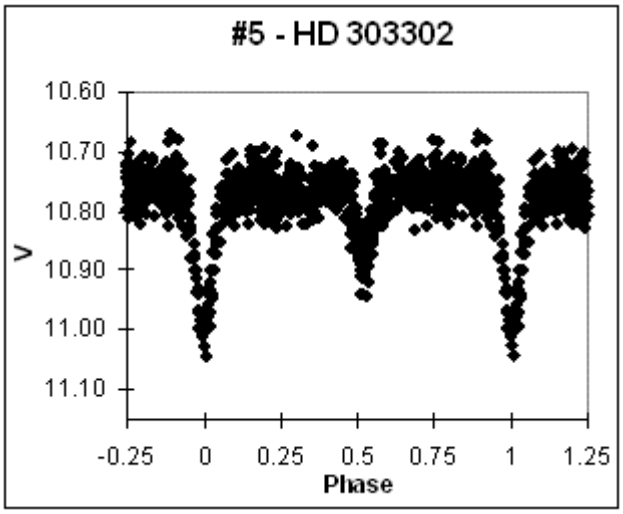

Fig. 5 – Lightcurve of HD 303302

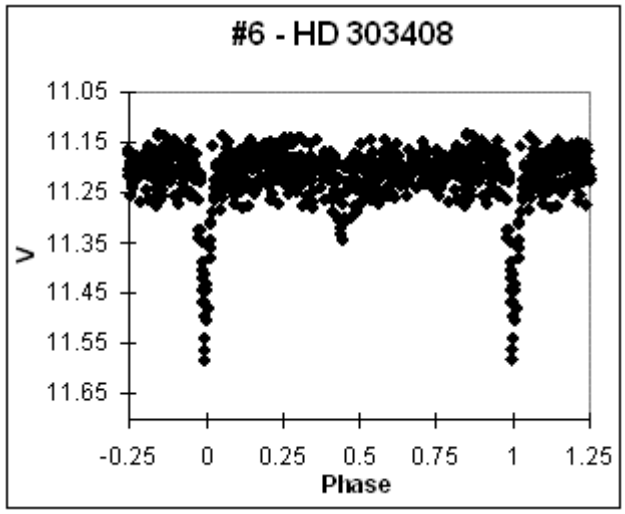

Fig. 6 – Lightcurve of HD 303408

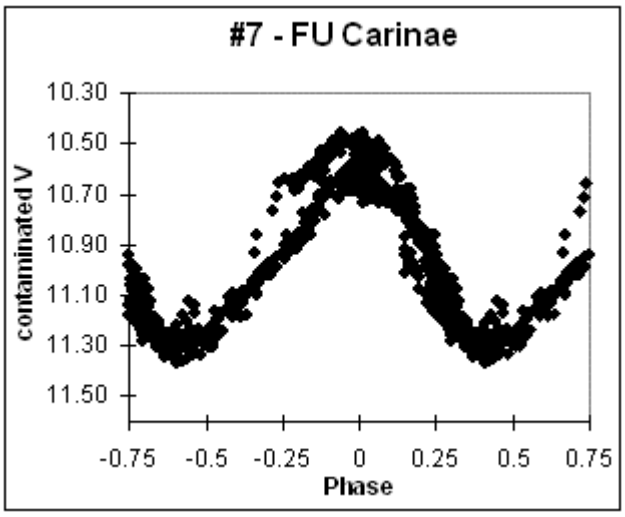

Fig. 7 – Lightcurve of FU Carinae. The magnitudes are for the combined light of the variable and a nearby star

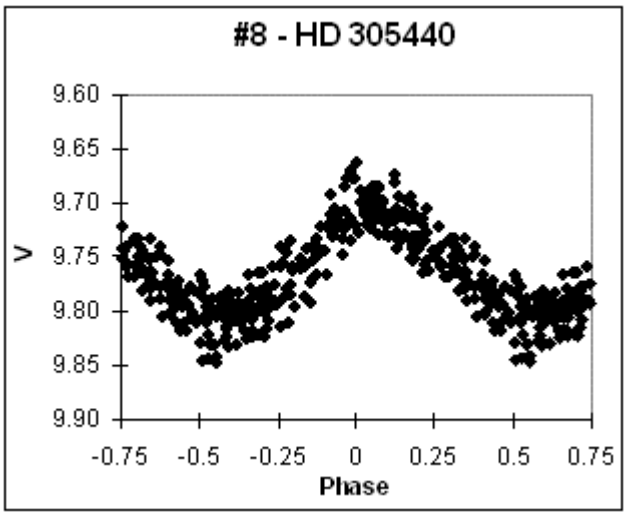

Fig. 8 – Lightcurve of HD 305440

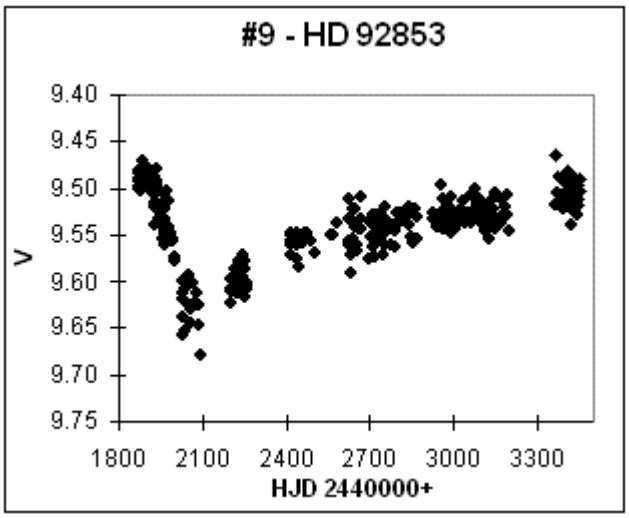

Fig. 9 – Lightcurve of HD 92853

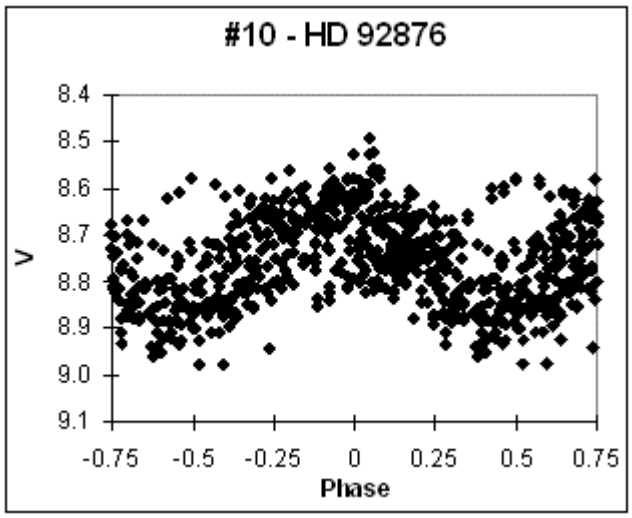

Fig 10 – Lightcurve of HD 92876

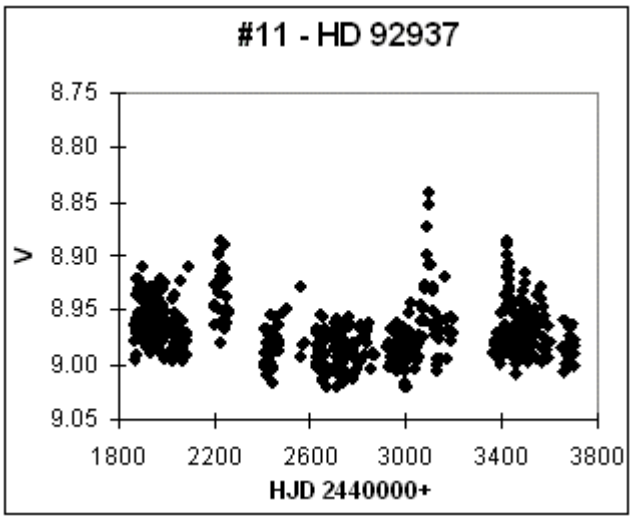

Fig. 11 – Lightcurve of HD 92937

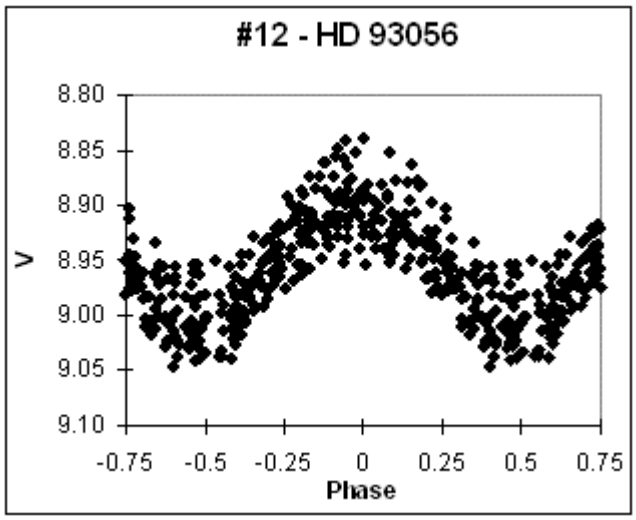

Fig. 12 – Lightcurve of HD 93056

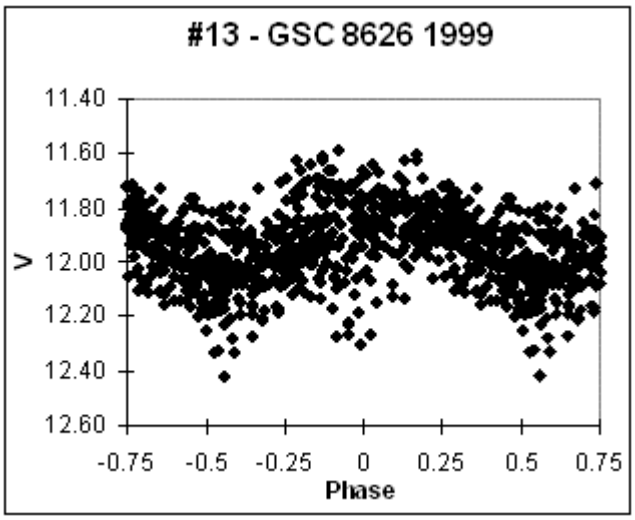

Fig. 13 – Lightcurve of GSC 8626 1999

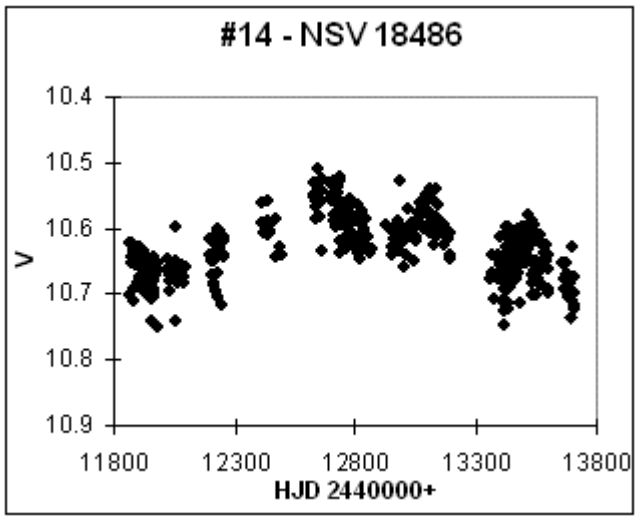

Fig. 14 – Lightcurve of NSV 18486. The magnitudes are for the combined light of the variable and a nearby star

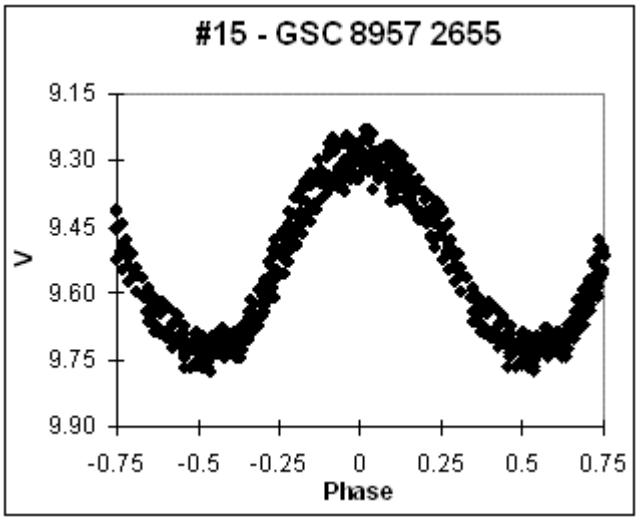

Fig. 15 – Lightcurve of GSC 8957 2655

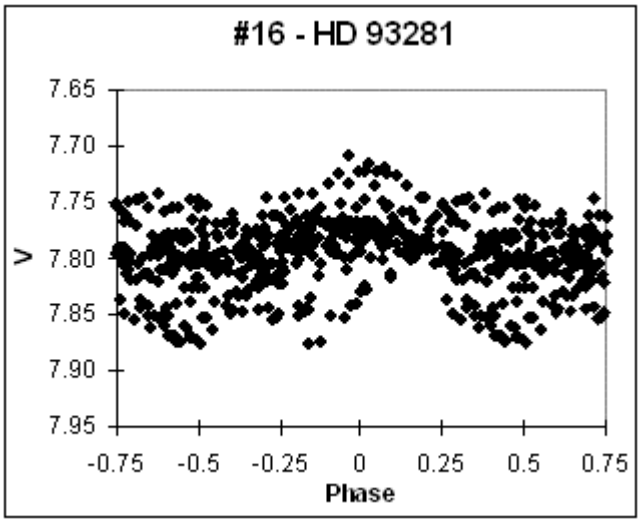

Fig. 16 – Lightcurve of HD 93281

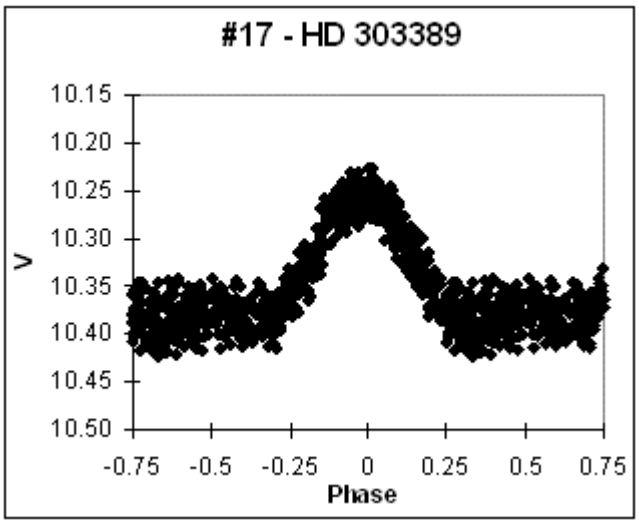

Fig. 17 – Lightcurve of HD 303389

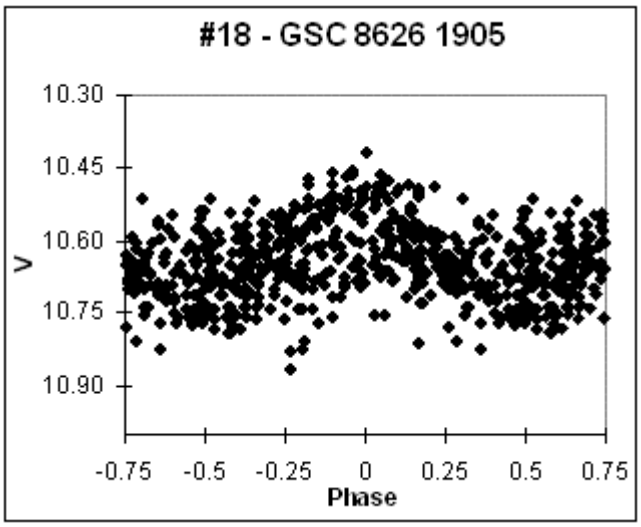

Fig. 18 – Lightcurve of GSC 8626 1905

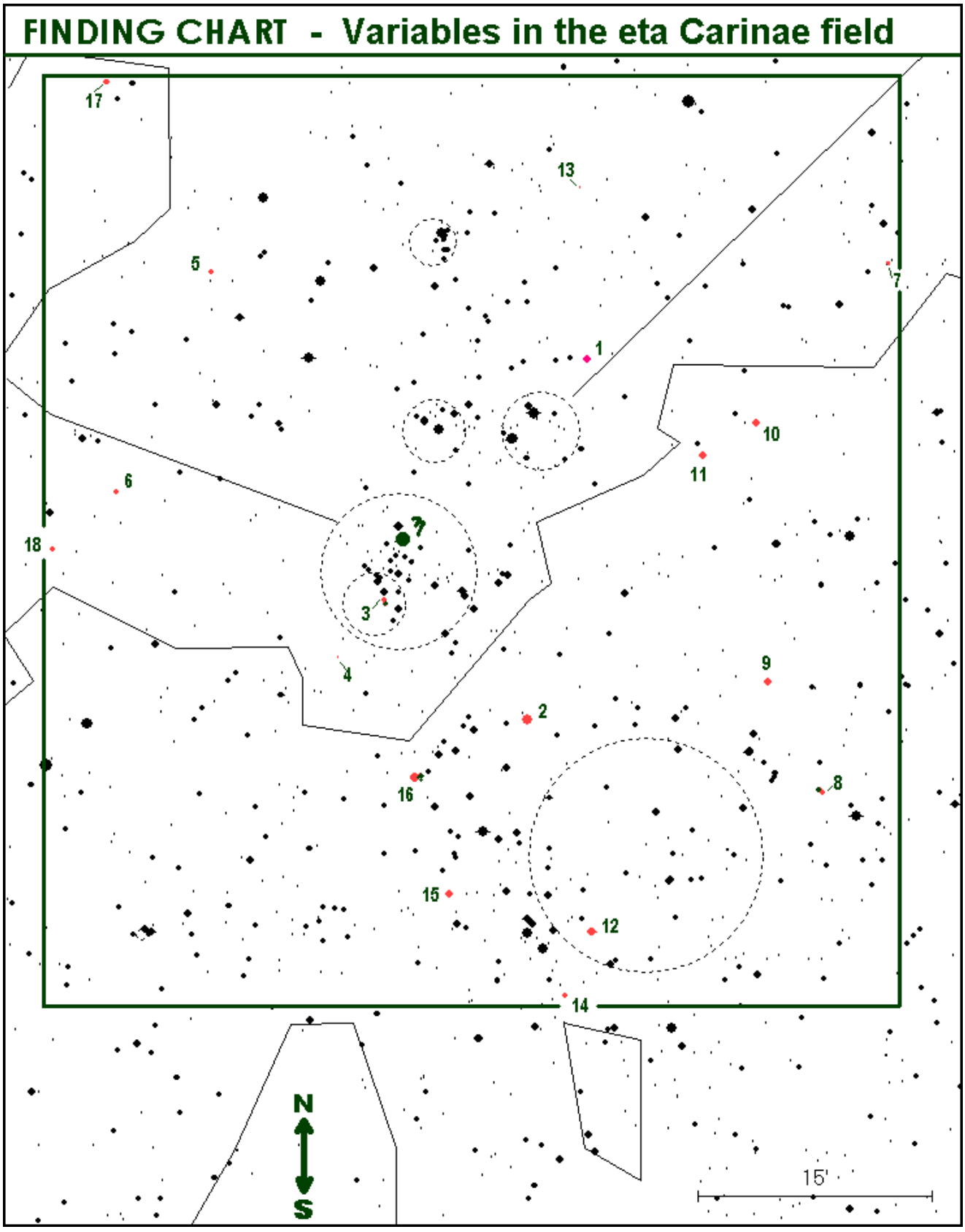

Fig. 19 – Finding chart for the 18 variable stars presented in this study

Acknowledgements: This research has made use of the SIMBAD and VizieR databases operated at the Centre de Données Astronomiques (Strasbourg) and also of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

References:

Albacete Colombo, J.F., Morrell, N.I., Niemela, V.S., Corcoran, M.F., 2001, MNRAS, 326, 78 (2001MNRAS.326...78A)

Buscombe, W., 1998, Northwestern Univ., Evanston, Illinois ISBN 0-939160-11-3, 13th General Catalogue of MK Spectral Classification (1998yCat.3206....0B)

Buscombe W., 1999, Northwestern Univ., Evanston, Illinois ISBN 0-939160-12-9, 14th General Catalogue of MK Spectral Classification (2001yCat.3222....0B)

Cruz-Gonzalez, C., Recillas-Cruz, E., Costero, R., Peimbert, M., Torres-Peimbert, S., 1974, Rev. Mex. Astron. Astrof., 1, 211, Catalogue of Galactic O Stars (1974RMxAA...1..211C)

Dommanget, J., Nys, O., 2002, Observations et Travaux 54, 5, Catalogue of the Components of Double and Multiple Stars (CCDM) (2002yCat.1274....0D)

Houk, N., Cowley, A.P., 1975, Dept. of Astronomy, Univ. of Michigan Ann Arbor, Catalogue of two dimensional spectral types for the HD stars, Vol. 1 (1975mctd.book.....H)

Kholopov, P.N. et al., 2005, The combined table of General Catalogue of Variable Stars vol I-III, 4th ed. (GCVS4) and Namelists of Variable Stars Nos.67-77 (http://www.sai.msu.su/groups/cluster/gcvs/gcvs/iii/)

Levato, H., Malaroda, S., Garcia, B., Morrell, N., Solivella, G., 1990, ApJS, 72, 323 (1990ApJS...72..323L)

Loden, L.O., Loden, K., Nordstroem, B., Sundman, A., 1976, A&AS, 23, 283, A Spectral Survey of the Southern Milky Way III. O-B9 and M Stars. l = 280deg to 306deg (1976A&AS...23..283L)

Mermilliod, J.-C., Hauck, B., Mermilliod, M., 1997, A&AS, 124, 349, General Catalogue of Photometric Data (GCPD) II (1997A&AS..124..349M)

Nesterov, V.V., et al., 1995, A&AS, 110, 367, The Henry Draper Extension Charts: A catalogue of accurate positions, proper motions, magnitudes and spectral types of 86933 stars (1995A&AS..110..367N)

Ochsenbein, F., 1980, Bull. Inf. CDS, 19, 74 (1980BICDS..19...74O)

Pojmanski, G., 2002, Acta Astronomica, 52, 397, The All Sky Automated Survey (2002AcA....52..397P)

Skiff, B.A., Lowell Observatory (2005), General Catalogue of Stellar Spectral Classifications (2004yCat.3233....0S)

Worley, C.E., Douglass, G.G., 1997, A&AS, 125, 523, The Washington Visual Double Star Catalog, 1996.0 (1997A&AS..125..523W)

Zacharias, N., Urban, S.E., Zacharias, M.I., Wycoff, G.L., Hall, D.M., Germain, M.E., Holdenried, E.R., Winter, L., 2004, AJ, 127, 3043 (2004AJ....127.3043Z)