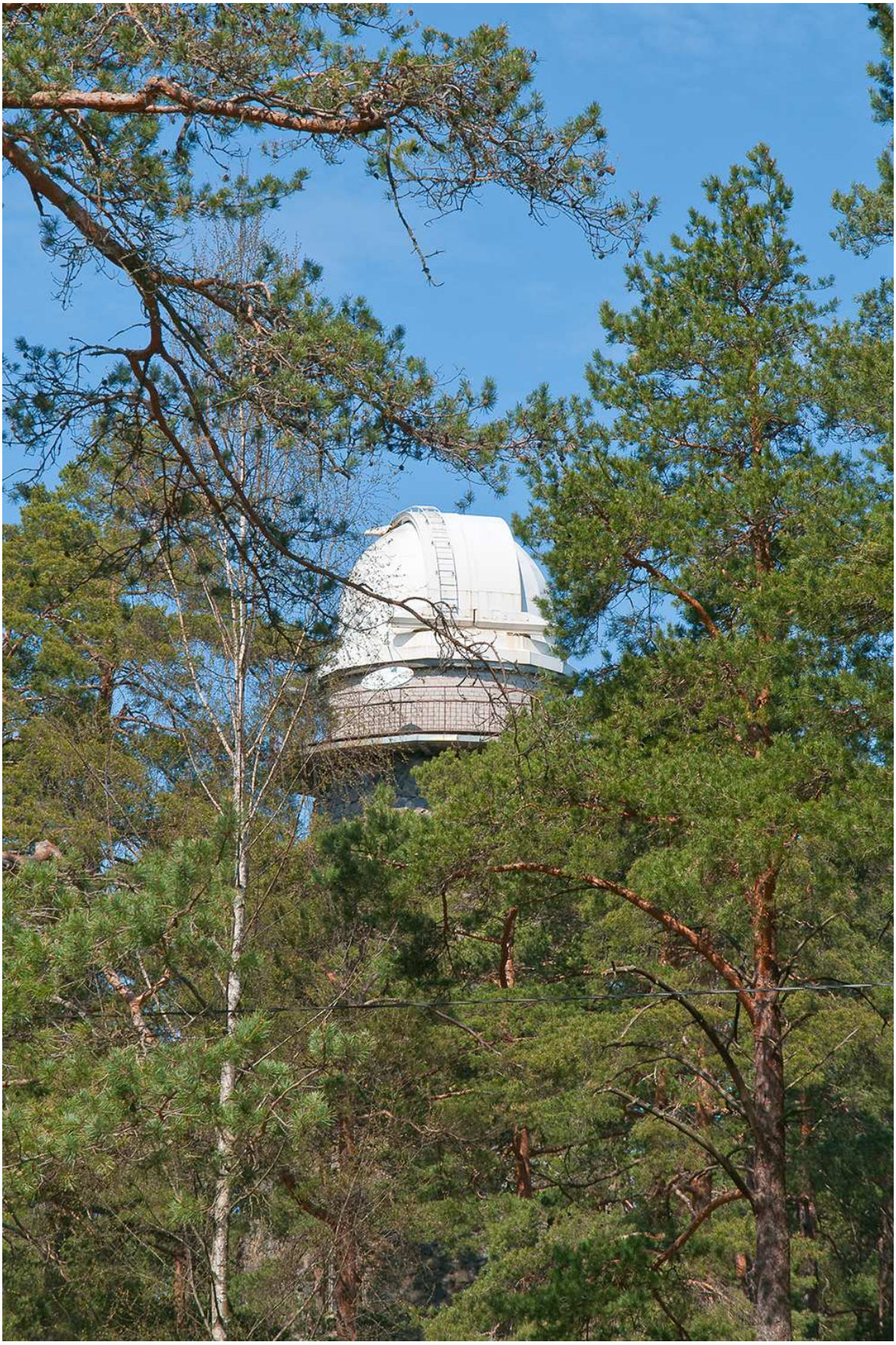
TALLINNA TÄHETORN
TALLINN OBSERVATORY

VI

Number 1

2009



Tallinna Tähetorn ⊙ Tallinn Observatory

TALLINNA TEHNIKAÜLIKOOL
FÜÜSIKAINSTITUUT
TALLINNA TÄHETORN

TALLINN UNIVERSITY OF TECHNOLOGY
INSTITUTE OF PHYSICS
TALLINN OBSERVATORY

TALLINNA TÄHETORN
TALLINN OBSERVATORY

VI

Number 1

TALLINN 2009

Koostanud ja toimetanud
T. Aas, V. Harvig, V.-V. Pustõnski

Tehniliste aruannete ja eelartiklite kogumik
Collections of technical reports and preliminary articles

ISSN 1406–8559

The observations of EM Cep and V497 Cep.

T. Aas[2], V. Harvig[1,2] and M. Mars[2]

[1]Tartu Observatory, Estonia
[2]Tallinn University of Technology, Physics Department, Ehitajate tee 5, 19086, Tallinn

Introduction

The open cluster NGC 7160 and specially the variable star EM Cep are frequently observed photometrically. The reasons for high interest to observation of EM Cep are that the star is bright, with a short period and that it is in the open cluster and suitable comparison and check stars are at very small angular distance and of similar color. The corrections for absorption are negligible.

The variability of EM Cep was discovered by Lynds (1959a,b). Johnston(1970) observed EM Cep photoelectrically in the fall 1968 on 14 nights. Rachkovskaia(1975,1976a, b) obtained UBV photoelectric and spectrophotometric (3600-4900Å) observations of EM Cep. She showed that the luminosity of EM Cep decreased by 0.5 magnitude in 1974 as compared to 1972 at both maximum and minimum light, while its color remained constant during the observations in 1974. A comparison of spectra obtained in 1971 and 1974 indicates that EM Cep is a normal star of spectral type B0.8 IV-V in terms of its atmospheric parameters and that its atmosphere is helium-rich, with a logarithmic helium-to-hydrogen ratio of -0.81. Tremko & Bakos (1980) on the ground of photoelectric observations in B-band confirm the irregular variations in brightness described by other authors. Breinhorst & Karimie (1980) observed EM Cep photoelectrically in the fall 1978. Harmanec (1984) restudied Rachkovskaias and other observations. He also gives thorough overview of earlier investigations of EM Cep. Kochiashvili (1999) and Kochiashvili et al. (2007) observed the flare events. Bakiş et al. (2007) described UBV photometric observations obtained in four seasons and one season of spectroscopic observation. A possible period of 0.403 days (half of usually used) and large light amplitude variations from one season to another were determined. A flare activity for this star has been detected on 17-18 July 2003. The brightness increase during the flare was found to be maximum in U-band. They supposed that the star could be a λ Eri type variable. They note that additional changes on the light curve do not show any periodicity. (Binarity problem of the star has been also discussed.)

Harmanec et al. (1999) confirmed variability of GSC 4266 1293, first suspected more than 20 years earlier, on the basis of observations from three observatories. The light of the star apparently varies with a period of $1\overset{\mathrm{d}}{.}2028251$, and a double-wave light curve exists. Five available radial velocities of the star also define a large-amplitude curve with the same period. They conclude, however, that it is more probably an ellipsoidal variable than an eclipsing binary. Yakut et al. (2003a, b) on the basis of new light curves and radial-velocity curves of V497 Cep, refined the linear ephemeris. They found that the observed light variation of V497 Cep consists of a strong ellipticity effect and a small contribution from grazing eclipses. Comparison of masses and radii of V497 Cep with theoretical evolutionary tracks indicates that both binary components are very close to the zero-age main sequence. Comparison of disentangled line profiles of the He I 6678 line with synthetic, rotationally broadened line profiles indicates that the rotation of both stars is synchronized with the orbital revolution as expected.

Figure 1: Open Cluster NGC 7160

Table 1: NGC 7160 Star List

⋆	GSC	SAO	HIP	HD	$U-B$	$B-V$	V	notes
1	4266 1787	19698	107984	208218	-0.$^{\rm m}$57	0.$^{\rm m}$24	6.$^{\rm m}$69	
2	4266 2575	19718	108073	208392	-0.56	0.26	7.04	EM Cep
3	4266 1263	19719	108080	208440	-0.73	0.07	7.90	the reference star for observations in 1987 and 2001
4	4266 1293	19711	108052		-0.46	0.17	8.92	V497 Cep
5	4266 863	19715			-0.49	0.18	9.34	the reference star for observations in 2008
6	4266 1949	19713			-0.33	0.23	9.83	
7	4266 1217				-0.49	0.15	10.01	

The distance to the cluster NGC 7160 was found to be about 760±100 pc which agrees well with other available estimates.

NSV 25788 = GSC 4266 1263 = SAO 19719 = HIP 108080 = HD 208440 is a suspected variable star but it is often used as comparison star for EM Cephei and V497 Cephei. Figer (1980) gives the finding map and Rufener (1989) provides brightness measurement. We do special efforts to solve the question of stability or variability of this star. The deviation

of measurements is higher then one can expect for all combinations of brightest stars of the cluster. No periodic variations in differential brightness of stars No. 1, 3, 5, 6 and 7 (Figure 1, Table 1) could be found. We can not explain this phenomenon. It is possible that circumstellar matter could be the reason of this phenomenon. However it seems that additional high-precision and high-time-resolution observations are needed.

For the reason that GSC 4266 1263 is „suspected“ we give the magnitude differences in respect to GSC 4266 863 for observations made in 2008. In 1987 and 2001 the reference star was GSC 4266 1263.

Observations

We observed EM Cep for the first time in 1987. We obtained light curves of EM Cep on four consecutive nights. The observations were carried out using the two-channel photon-counting photoelectric system attached to the 48 cm reflector of the Vilnius Observatory High-Altitude Station on Mount Maidanak (near Samarkand, Uzbekistan). This system has been specially designed for searching rapid variations by simultaneous measurements of the variable and a comparison star. The photoelectric system was equipped with the unrefrigerated photomultiplier's FEU-79. The V-filters of the UBV-system and the integration time of 100 seconds for a single observation were used. The observational standard error of an individual observation was $0\overset{\mathrm{m}}{.}003$. The star GSC 4266 1263 served as a comparison star. The individual differential observations are plotted in Figure 4 and given in Table 7. In 2001 we observed EM Cep at Tallinn Observatory, but the combination of SBIG ST-7 CCD camera and AZT-14 telescope gives the field of view of only 3 arcmin and there are not enough check stars to secure the requisite precision of to be sure in stability of GSC 4266 1263. In September and October 2008 the open cluster NGC 7160 was observed in 20 nights at the Hlohovec Observatory. The Cassegrain 600/7500 mm telescope was used with the camera SBIG ST-9XE. The UBVRI Bessel color photometric filters (made by the Institute of Plasma Physics in Czech Republic) were used. The field of view of this system was 15 arcmin.

Results and discussion

As strange as it could seam, but despite of efforts of a number of investigators during more then 50 years there are a lot of elementary problems still open around EM Cep. First of all, EM Cep shows light curve similar to a binary star and it was classified as eclipsing binary for a long time. But in the same time no radial velocity variations could be found. Then Kochiashvili (1999) interpreted the light variations as a result of gas eclipse (Pustylnik & Einasto 1984, 1985a,b, 1987), and since 2007 λ Eri type variable interpretation is common: Kochiashvili et al. (2007) and Bakiş et al.(2007). We obtained a complete V-light-curve at Maidanak Observatory, a partial V-light-curve at Tallinn Observatory and BVRI complete-light-curves at Hlohovec Observatory.

From our observations of EM Cep we find five additional times of minima what are roughly in a rather good agreement with other measurements. The great scattering of points on O-C diagram is a result of instability of the shape of the light curve. As one can see form Figures 3, 4 and Table 2, the period of EM Cep is changing. We derived light-elements with quadratic member:

$$\text{JD Hel.}=2440134.7359 + 0\overset{\mathrm{d}}{.}806186 \times E - 3\overset{\mathrm{d}}{.}20935 \cdot 10^{-10} \times E^2$$

V497 Cep is an important interacting binary as a member of a young open cluster. From our observations new BVRI-complete light-curves are available and new minima are:

JD Hel. = $2446299^{d}.237+1^{d}.2028251*E$

Epoch	(O-C)	JD Hel.	p/s
7032	$-0^{d}.047\pm0^{d}.004$	2454757.4561	p
7032	$-0^{d}.052\pm0^{d}.005$	2454758.0525	s

Acknowledgements. We are greatly indebted to the staff members of Vilnius Observatory for their assistance in observations and to Karol Petric from Hlohovec Observatory who made possible to use observational time. We are thankful to Dr. Pustynski for checking the manuscript. This investigation was supported by the Grant No. 7691 of the Estonian Science Foundation.

References

Bakiş, V., Demircan, O., Budding, E. & Tanriver, M., 2007, Solar and Stellar Physics Through Eclipses, 370, 225 81.

Breinhorst, R. A., & Karimie, M. T., 1980, PASP, 92, 432

Dreyer, J. L. E.,1888, MmRAS..49....1D, 49, 1

Figer, A.,GEOS NC No.262, 1980

Harmanec, P., 1984, Bulletin of the Astronomical Institutes of Czechoslovakia, 35, 193

Harmanec, P., Božić, H., Eenens, P., & ŽiŽňovský, J. 1999, A&A, 346, 87

Hill, G.,1967, ApJS, 14, 301

Hoag, A.A., Johnson, H.L., Iriarte, B., Mitchll, R.I., Hallam, K.L. and Sharpless, S., 1961, Publications of the U.S. Naval Observatory Second Series, 17, 345

Kochiashvili, N. T., 1999, Astrophysics, 42, 399

Kochiashvili, N., Natsvlishvili, R., Bakis, H., & Tanriver, M. 2007, Astronomical and Astrophysical Transactions, 26, 113

Johnston, K., 1970, PASP...82.1093J

Lynds, C. R., 1959, ApJ, 130, 577

Lynds, C. R., 1959, ApJ, 130, 603

Pustylnik, I. B., & Einasto, L., 1984, Pisma Astronomicheskii Zhurnal, 10, 516

Pustylnik, I. B., & Einasto, L., 1985a, Abastumanskaia Astrofizicheskaia Observatoriia Biulleten, 58, 12

Pustylnik, I. B., & Einasto, L., 1985b, Pisma Astronomicheskii Zhurnal, 11, 873

Pustylnik, I. B., & Einasto, L. 1987, Pisma Astronomicheskii Zhurnal, 13, 603

Rachkovskaia, T. M., 1975, Izvestiya Ordena Trudovogo Krasnogo Znameni Krymskoj Astrofizicheskoj Observatorii, 53, 168

Rachkovskaia, T. M., 1976, Izvestiya Ordena Trudovogo Krasnogo Znameni Krymskoj Astrofizicheskoj Observatorii, 55, 100

Rachkovskaia, T. M., 1976, Izvestiya Ordena Trudovogo Krasnogo Znameni Krymskoj Astrofizicheskoj Observatorii, 56, 11

F.Rufener, AsAp Suppl 78, No.3, 469, 1989

Tremko, J., & Bakos, G. A., 1980, JRASC, 74, 321

Yakut, K., Tarasov, A. E., İbanoğlu, C., Harmanec, P., Kalomeni, B., Holmgren, D. E., Božić, H., & Eenens, P., 2003, A&A, 405, 1087

Yakut, K., Tarasov, A. E., Ibanoglu, C., Harmanec, P., Kalomeni, B., Holmgren, D. E., Bozic, H., & Eenens, P., 2003, VizieR Online Data Catalog, 340, 51087

EM Cep ja V497 Cep vaatlustest

Meie huvi noore hajusparve NGC 7160 vaatluste vastu sai alguse üle 20 aasta tagasi. Tollal teostati mitmeid astrokliima ekspeditsioone Maidanaki mäele. Siis oli EM Cep vaatlemine kõrvalsaaduseks. Hiljem vaatluste töötlemisel tundusid tulemused kummalised. Üldiste arusaamade järgi peeti EM Cephei'd lühiperioodiliseks nooreks Be varjutusmuutlikuks kaksiktäheks. Kuna vaatluste põhieesmärgiks oli astrokliima uurimine, pöörasime erilist tähelepanu vaatlustäpsusele. Veendusime, et vaatluste neljal järjestikusel ööl oli mõõtmiste määramatus väiksem kui $0\overset{\mathrm{m}}{.}003$, kuid EM Cep - GSC 4266 1263 heleduskõveral olid jälgitavad kuni $0\overset{\mathrm{m}}{.}05$ küündivad kiired kõrvalekalded. Juba siis oli kirjanduslikest allikatest selge, et EM Cep ei ole „õige" varjutusmuutlik täht. Kuna selleks ajaks oli kõige rohkem vaadeldud EM Cephei'd kasutades võrdlustähena GSC 4266 1787 (Rachkovskaia) ja GSC 4266 1263, mis osutus muutlikkuses kahtlustatavaks täheks, siis püüdsime jõuda selgusele viimase stabiilsuse suhtes. Tallinnas teostatud vaatlused aga ei andnud sellele küsimusele usaldusväärset vastust. Slovakkias teostatud vaatluste põhieesmärgiks oligi jõuda selgusele GSC 4266 1263 stabiilsuse küsimuses. Sedapuhku on põhjust järjekordselt järeldada, et tulemused on põhiliselt kõrvaltulemused. EM Cep 11713 (2902+2918+2956+2937) ja V497 12802 (3170+3189+3233+3210) kõigis BVRI teostatud CCD vaatluse põhjal ei saa ikkagi kindlaid järeldusi teha. Teatud määral on loodetust suurem hajumine tingitud lühikese eksposits iooniaja kasutamisest, kuna teleskoop oli selleks otstarbeks liiga suur ja ei õnnestunud igal õhtul ja hommikul saada tasavälja kaadreid. Nii ongi, nagu vaatlejatel ikka, vaja veel vaatlusi. Seniste vaatluste tulemusel oleme saanud uued täielikud EM Cep ja V497 Cep heleduskõverad ja määranud lisa normaalminimumid. EM Cep jaoks leidsime uued valguselemendid koos ruutliikmega:

$$\text{JD Hel.}=2440134\overset{\mathrm{d}}{.}7359 + 0\overset{\mathrm{d}}{.}806186 \times E - 3\overset{\mathrm{d}}{.}20935 \cdot 10^{-10} \times E^2)$$

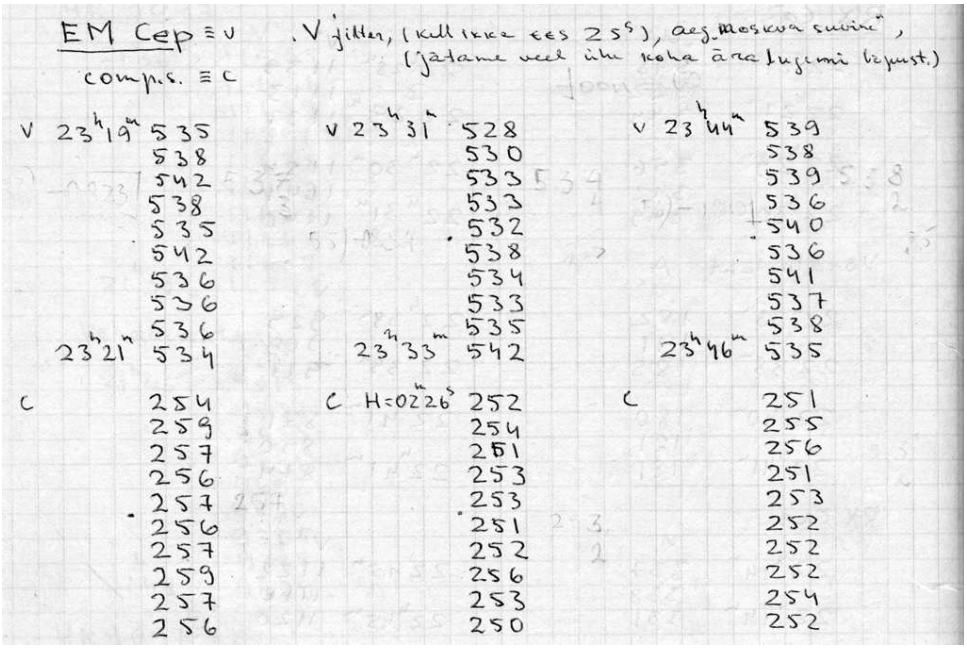


Figure 2: Näide kahekanalilise fotomeetrilise süsteemi „registrogrammist" aastast 1987. Tollal olid printerid sedavõrd defitsiitsed, et praegu tundub see isegi vanale inimesele uskumatu. Näiteks võis helikopter tuua vaatlusbaasi paar arbuusi, mille hind oli ilmselt tuhandeid kordi väiksem transpordi maksumusest - see näide peaks kinnitama, et rahas ei olnud küsimus. Ega ka printerite hinnad ei olnud eriti kõrged.

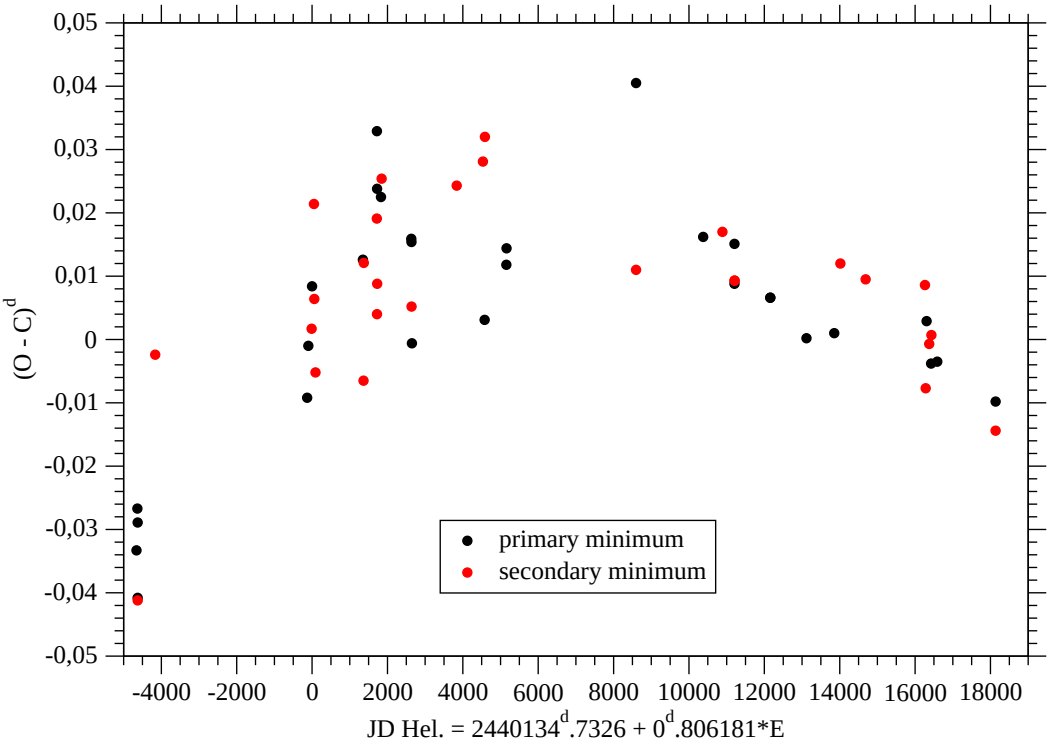


Figure 3: O–C graph according linear light elements

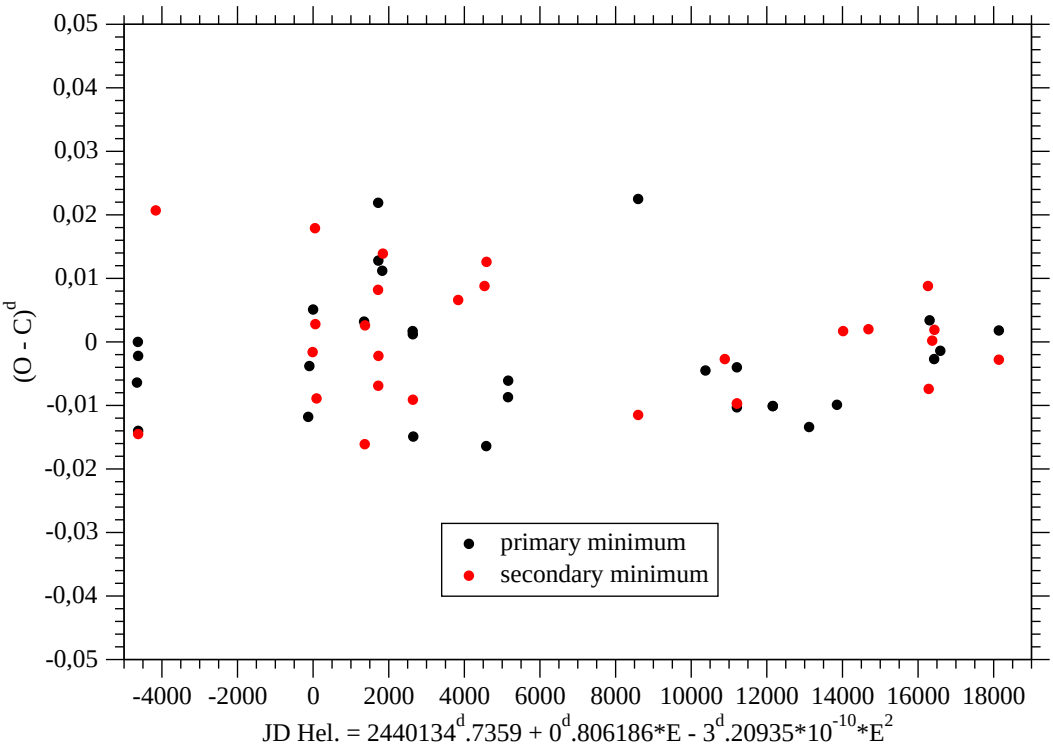


Figure 4: O–C graph according light-elements with quadratic member

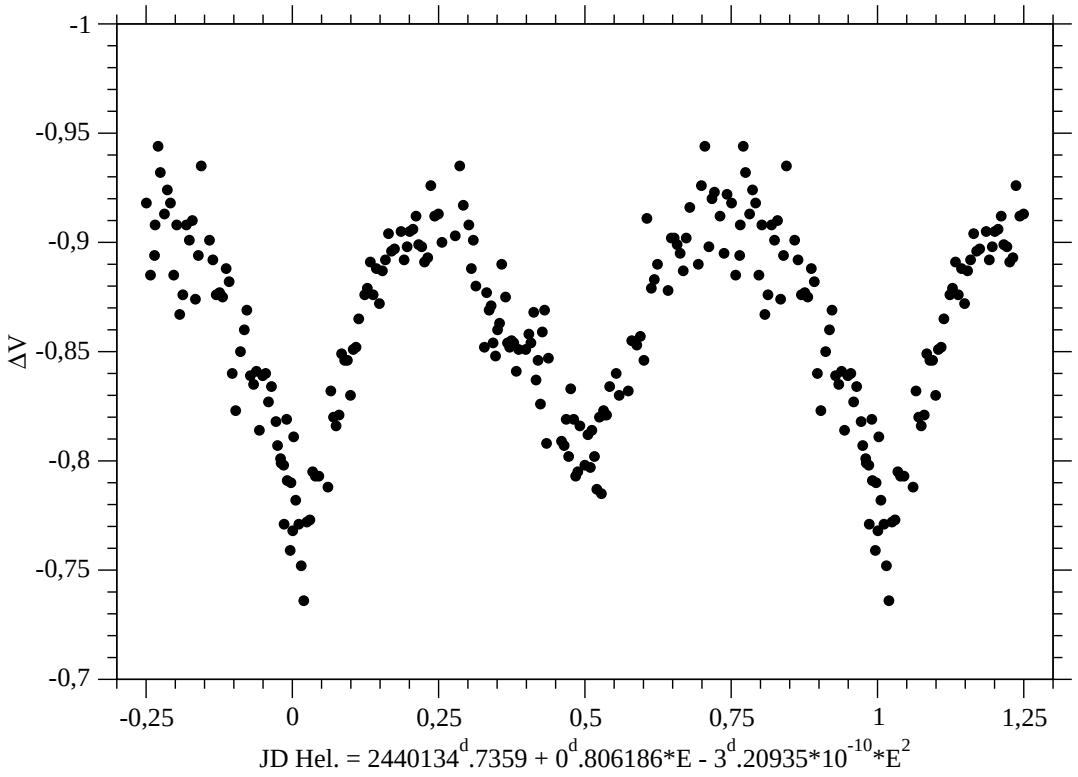


Figure 5: Light curve of EM Cep in 1987 (Maidanak)

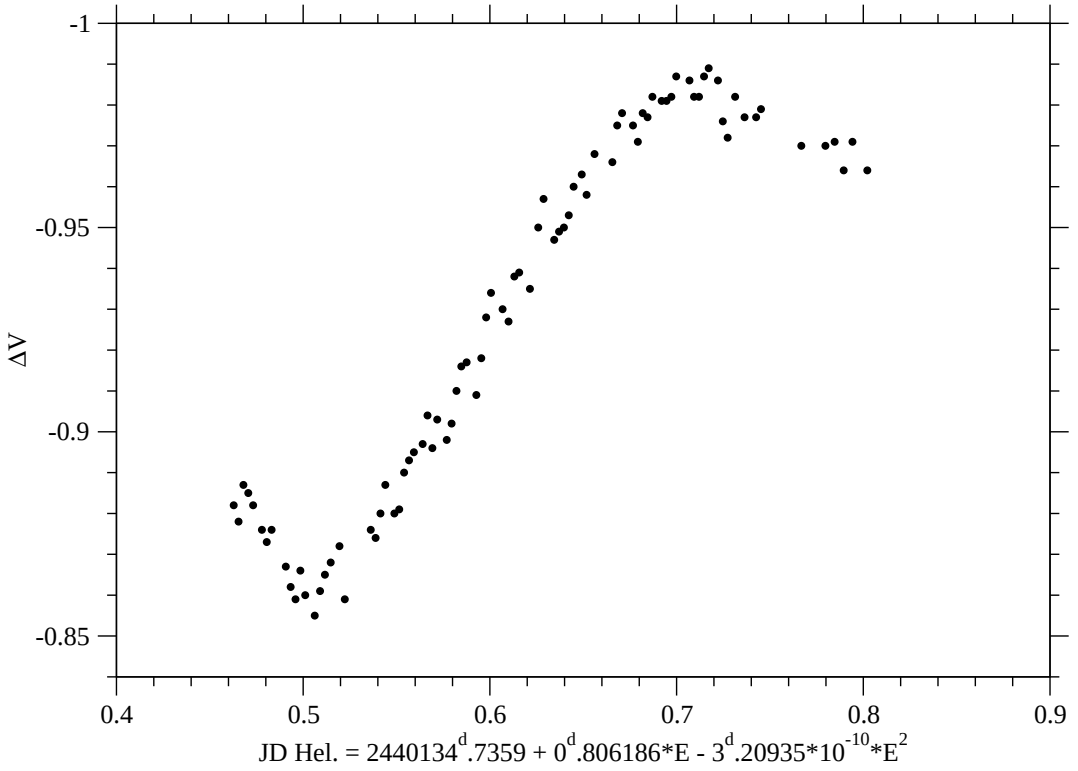


Figure 6: Light curve of EM Cep in 2001 (Tallinn)

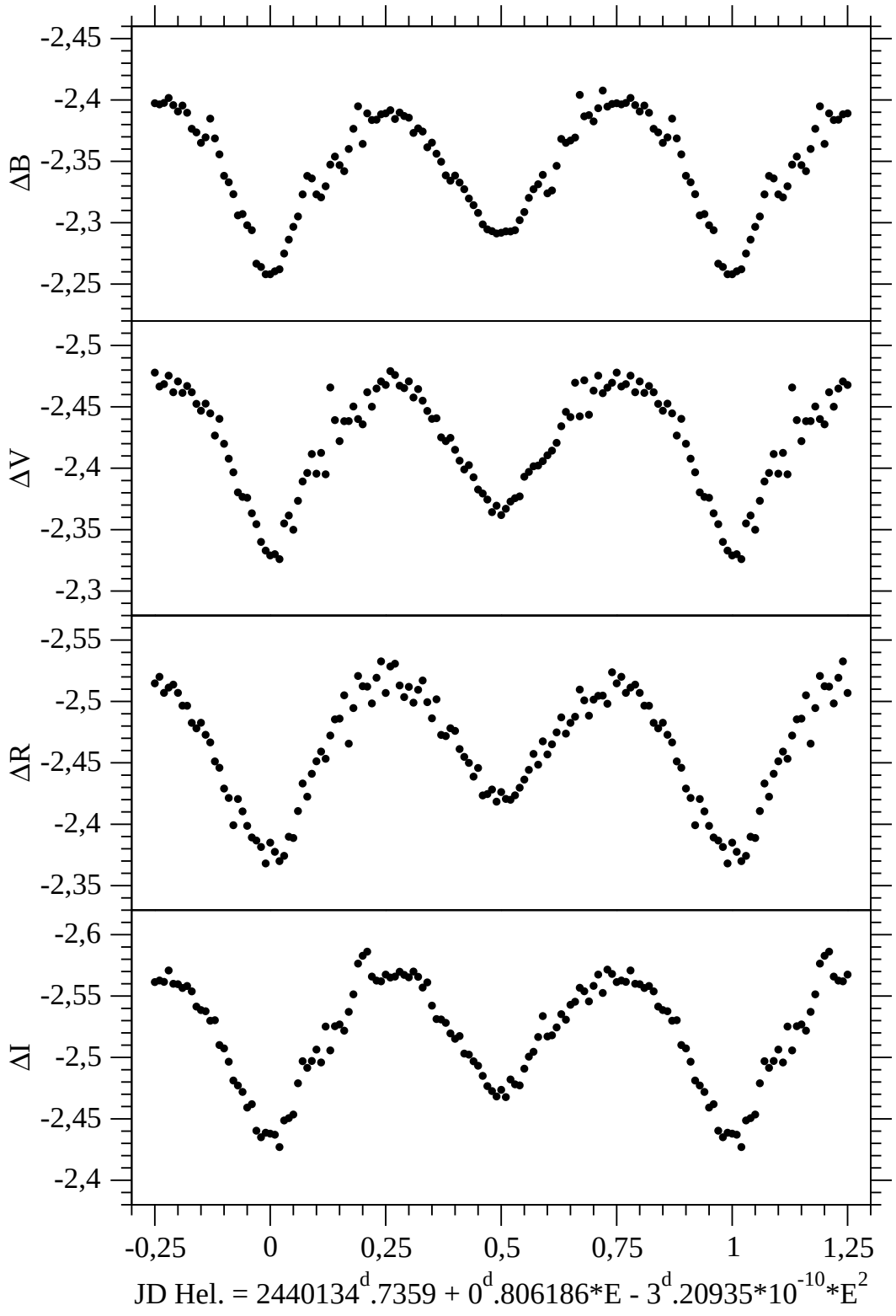


Figure 7: Light curves of EM Cep in 2008 (Hlohovec)

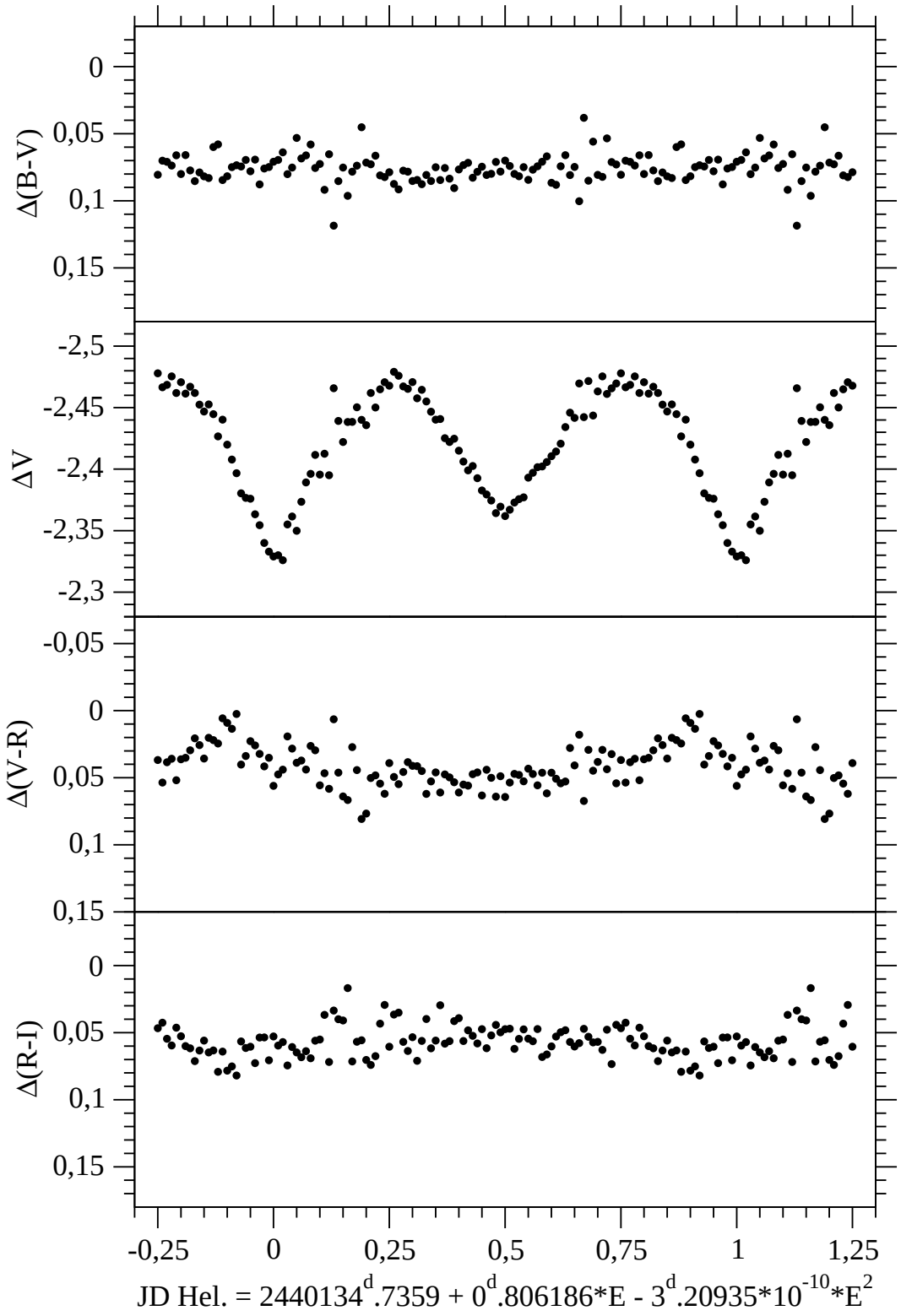


Figure 8: Colour curves of EM Cep in 2008 (Hlohovec)

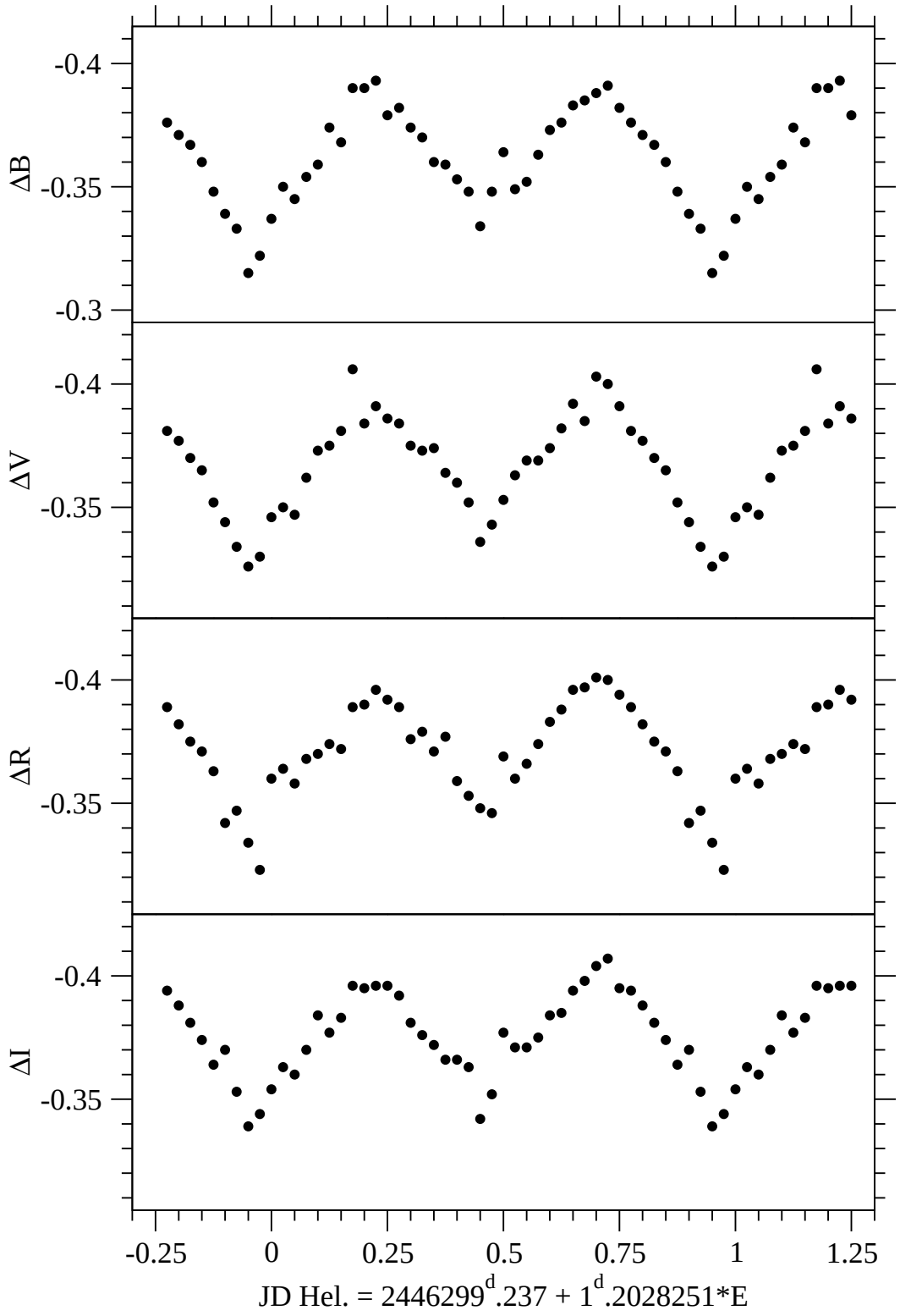


Figure 9: Light curves of V497 Cep in 2008 (Hlohovec)

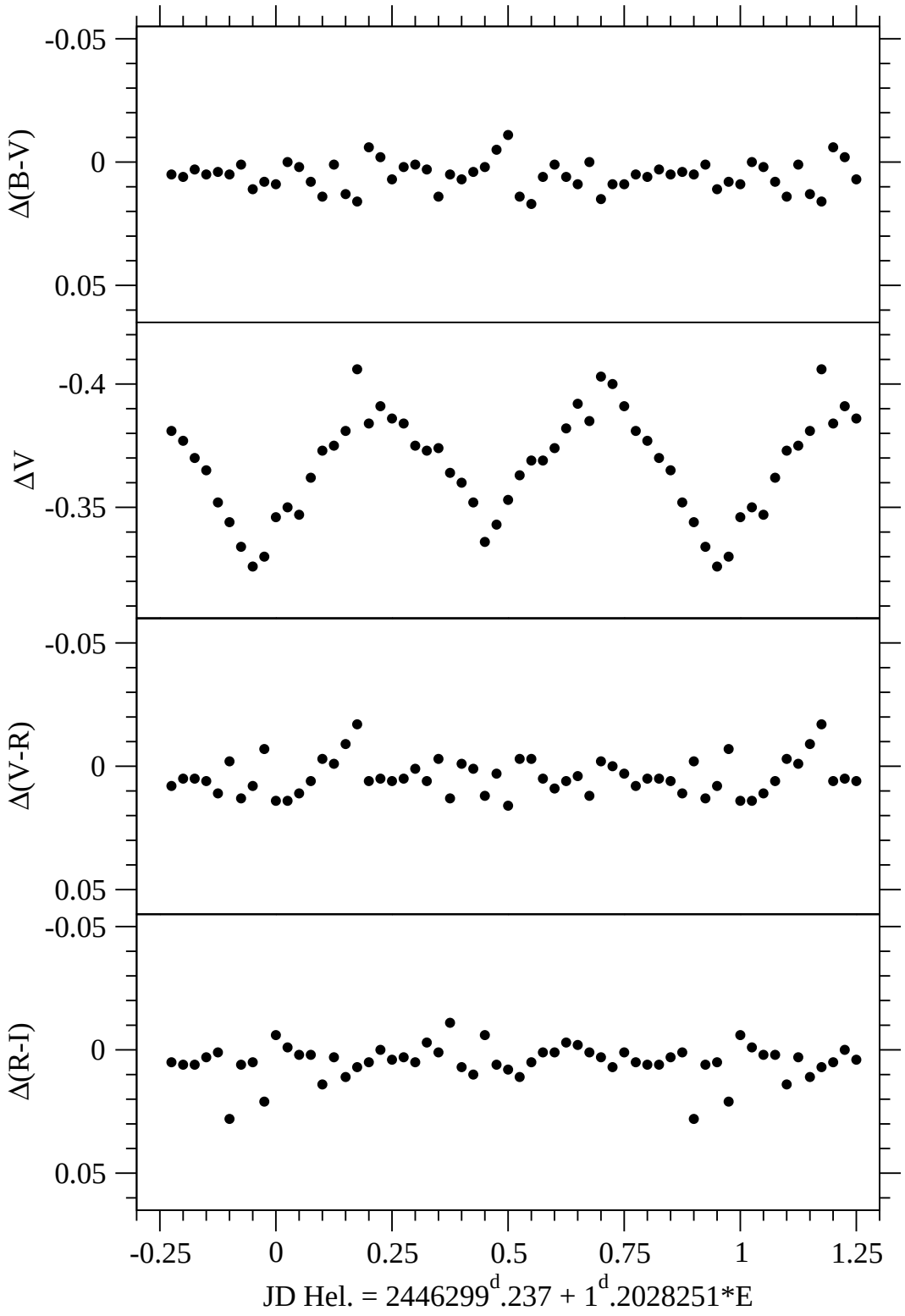


Figure 10: Colour curves of V497 Cep in 2008 (Hlohovec)

Table 2: O–C values for EM Cep according different light elements

Epoch	$(O-C)_{lin}$	$(O-C)_{quad}$	HJDmin	p/s	Method	Observer
-4659	-0.0333	-0.0064	2436378.7020	p	pe	Lynds C R
-4634	-0.0267	0.0000	36398.8631	p	pe	Lynds C R
-4629	-0.0408	-0.0140	36402.8800	p	pe	Lynds C R
-4628	-0.0289	-0.0022	36403.6980	p	pe	Lynds C R
-4627	-0.0412	-0.0145	36404.8950	s	pe	Lynds C R
-4162	-0.0024	0.0207	36779.8080	s	pe	Lynds C R
-130	-0.0092	-0.0118	40029.9199	p	pe	Breinhorst R A
-99	-0.0010	-0.0038	40054.9197	p	pe	Breinhorst R A
-13	0.0017	-0.0016	40124.6570	s	pe	Johnston K
0	0.0084	0.0051	40134.7410	p	pe	Johnston K
49	0.0214	0.0179	40174.6600	s	pe	Johnston K
60	0.0064	0.0028	40183.5130	s	pe	Johnston K
91	-0.0052	-0.0089	40208.4930	s	pe	Johnston K
1349	0.0126	0.0032	41222.2834	p	pe	Rachkovskaya T M
1366	-0.0065	-0.0161	41236.3724	s	pe	Rachkovskaya T M
1371	0.0121	0.0026	41240.4220	s	pe	Rachkovskaya T M
1717	0.0191	0.0082	41519.3676	s	pe	Rachkovskaya T M
1720	0.0329	0.0219	41521.3968	p	pe	Rachkovskaya T M
1722	0.0040	-0.0069	41523.3834	s	pe	Rachkovskaya T M
1725	0.0238	0.0128	41525.4186	p	pe	Rachkovskaya T M
1727	0.0088	-0.0022	41527.4191	s	pe	Rachkovskaya T M
1828	0.0225	0.0137	41608.4540	p	pe	Bakos
1845	0.0254	0.0139	41622.5650	s	pe	Bakos
2633	0.0159	0.0017	42257.4231	p	pe	Rachkovskaya T M
2638	0.0154	0.0012	42261.4535	p	pe	Rachkovskaya T M
2640	0.0052	-0.0091	42263.4587	s	pe	Rachkovskaya T M
2648	-0.0006	-0.0149	42269.4993	p	pe	Rachkovskaya T M
3837	0.0243	0.0066	43228.4765	s	pe	Kreiner
4534	0.0281	0.0088	43790.3885	s	pe	Karimie M T
4578	0.0031	-0.0164	43825.4323	p	pe	Karimie M T
4586	0.0320	0.0126	43832.3138	s	pe	Karimie M T
5155	0.0118	-0.0087	44290.6075	p	pe	Tremko
5160	0.0144	-0.0061	44294.6410	p	pe	Tremko
8596	0.0405	0.0225	47064.7095	p	pe	Harvig V
8596	0.0110	-0.0115	47065.0786	s	pe	Harvig V
10377	0.0162	-0.0045	48500.4890	p	V	Hipparcos
10887	0.0170	-0.0027	48912.0452	s	pe	Skillman D R
11208	0.0088	-0.0103	49170.4180	p	V	Agerer Franz
11208	0.0151	-0.0040	49170.4243	p	B	Agerer Franz
11210	0.0093	-0.0097	49172.4340	s	V	Agerer Franz
11210	0.0093	-0.0097	49172.4340	s	B	Agerer Franz
12157	0.0066	-0.0101	49935.4816	p	V	Agerer Franz
12157	0.0066	-0.0101	49935.4816	p	B	Agerer Franz
13117	0.0002	-0.0134	50709.4090	p	UBV	Ak Hassan
13854	0.0010	-0.0099	51303.5652	p	ccd	Husar Dieter
14017	0.0120	0.0017	51435.3868	s	V	Agerer Franz
14688	0.0095	0.0020	51976.3317	s	ccd	Harvig V
16261	0.0086	0.0088	53244.4535	s	V	Bakis Volkan
16282	-0.0077	-0.0074	53261.3670	s	U	Bakis Volkan
16306	0.0029	0.0034	53280.3229	p	U	Bakis Volkan
16375	-0.0007	0.0002	53336.3489	s	BV	Bakis Volkan
16425	-0.0038	-0.0027	53376.2517	p	BV	Bakis Volkan
16432	0.0007	0.0019	53382.3026	s	BV	Bakis Volkan
16589	-0.0035	-0.0014	53508.4657	p	BV	Bakis Volkan
18136	-0.0098	0.0018	54755.6214	p	ccd	Mars M
18136	-0.0144	-0.0028	54756.0199	s	ccd	Mars M

Table 3: EM Cep normal light-curves data for 2008

Phase	ΔB	ΔV	ΔR	ΔI	Phase	ΔB	ΔV	ΔR	ΔI
0.00	-2.258	-2.329	-2.385	-2.438	0.50	-2.292	-2.362	-2.426	-2.474
0.01	-2.260	-2.330	-2.377	-2.437	0.51	-2.293	-2.367	-2.421	-2.468
0.02	-2.262	-2.326	-2.370	-2.427	0.52	-2.293	-2.373	-2.420	-2.482
0.03	-2.275	-2.355	-2.374	-2.449	0.53	-2.294	-2.376	-2.424	-2.478
0.04	-2.286	-2.361	-2.390	-2.451	0.54	-2.302	-2.377	-2.430	-2.477
0.05	-2.297	-2.350	-2.389	-2.454	0.55	-2.309	-2.393	-2.436	-2.491
0.06	-2.305	-2.373	-2.411	-2.479	0.56	-2.320	-2.397	-2.444	-2.501
0.07	-2.323	-2.389	-2.433	-2.497	0.57	-2.327	-2.402	-2.457	-2.505
0.08	-2.338	-2.396	-2.422	-2.492	0.58	-2.331	-2.402	-2.448	-2.517
0.09	-2.336	-2.412	-2.441	-2.497	0.59	-2.339	-2.406	-2.467	-2.534
0.10	-2.323	-2.396	-2.451	-2.506	0.60	-2.324	-2.411	-2.457	-2.517
0.11	-2.321	-2.413	-2.459	-2.496	0.61	-2.326	-2.414	-2.465	-2.518
0.12	-2.330	-2.395	-2.453	-2.525	0.62	-2.346	-2.421	-2.475	-2.524
0.13	-2.347	-2.466	-2.472	-2.506	0.63	-2.368	-2.434	-2.487	-2.535
0.14	-2.354	-2.439	-2.485	-2.525	0.64	-2.365	-2.446	-2.474	-2.531
0.15	-2.347	-2.422	-2.486	-2.527	0.65	-2.367	-2.442	-2.483	-2.543
0.16	-2.342	-2.438	-2.505	-2.522	0.66	-2.369	-2.470	-2.488	-2.545
0.17	-2.360	-2.438	-2.466	-2.537	0.67	-2.404	-2.442	-2.510	-2.557
0.18	-2.377	-2.450	-2.495	-2.551	0.68	-2.387	-2.472	-2.501	-2.554
0.19	-2.395	-2.440	-2.521	-2.576	0.69	-2.388	-2.444	-2.488	-2.546
0.20	-2.364	-2.436	-2.512	-2.583	0.70	-2.383	-2.463	-2.501	-2.558
0.21	-2.389	-2.462	-2.512	-2.586	0.71	-2.393	-2.475	-2.505	-2.567
0.22	-2.384	-2.450	-2.498	-2.566	0.72	-2.408	-2.461	-2.505	-2.553
0.23	-2.384	-2.465	-2.519	-2.563	0.73	-2.395	-2.466	-2.498	-2.572
0.24	-2.388	-2.471	-2.533	-2.562	0.74	-2.397	-2.470	-2.524	-2.568
0.25	-2.389	-2.468	-2.507	-2.567	0.75	-2.397	-2.478	-2.515	-2.561
0.26	-2.392	-2.479	-2.529	-2.565	0.76	-2.396	-2.467	-2.520	-2.563
0.27	-2.385	-2.476	-2.531	-2.566	0.77	-2.398	-2.469	-2.507	-2.562
0.28	-2.390	-2.467	-2.513	-2.570	0.78	-2.402	-2.475	-2.511	-2.571
0.29	-2.387	-2.465	-2.504	-2.567	0.79	-2.396	-2.462	-2.514	-2.560
0.30	-2.386	-2.471	-2.512	-2.565	0.80	-2.391	-2.471	-2.507	-2.560
0.31	-2.373	-2.458	-2.499	-2.570	0.81	-2.396	-2.461	-2.497	-2.557
0.32	-2.377	-2.465	-2.510	-2.566	0.82	-2.390	-2.467	-2.497	-2.558
0.33	-2.374	-2.455	-2.517	-2.557	0.83	-2.377	-2.462	-2.483	-2.554
0.34	-2.361	-2.447	-2.499	-2.561	0.84	-2.374	-2.452	-2.478	-2.541
0.35	-2.365	-2.440	-2.486	-2.542	0.85	-2.365	-2.447	-2.483	-2.539
0.36	-2.356	-2.441	-2.502	-2.531	0.86	-2.370	-2.453	-2.473	-2.538
0.37	-2.350	-2.425	-2.473	-2.531	0.87	-2.385	-2.445	-2.467	-2.530
0.38	-2.339	-2.422	-2.472	-2.528	0.88	-2.369	-2.427	-2.451	-2.530
0.39	-2.334	-2.425	-2.478	-2.520	0.89	-2.356	-2.440	-2.446	-2.510
0.40	-2.338	-2.415	-2.476	-2.515	0.90	-2.338	-2.420	-2.429	-2.507
0.41	-2.333	-2.406	-2.461	-2.517	0.91	-2.333	-2.408	-2.421	-2.496
0.42	-2.327	-2.399	-2.455	-2.503	0.92	-2.323	-2.397	-2.399	-2.481
0.43	-2.320	-2.403	-2.450	-2.502	0.93	-2.306	-2.380	-2.421	-2.477
0.44	-2.314	-2.393	-2.439	-2.497	0.94	-2.307	-2.377	-2.410	-2.472
0.45	-2.308	-2.383	-2.446	-2.493	0.95	-2.298	-2.376	-2.399	-2.459
0.46	-2.299	-2.379	-2.423	-2.485	0.96	-2.294	-2.363	-2.389	-2.462
0.47	-2.295	-2.375	-2.425	-2.477	0.97	-2.267	-2.354	-2.387	-2.440
0.48	-2.293	-2.364	-2.428	-2.473	0.98	-2.264	-2.340	-2.381	-2.435
0.49	-2.291	-2.370	-2.418	-2.468	0.99	-2.258	-2.333	-2.368	-2.439

Table 4: EM Cep normal color-curves data for 2008

Phase	Δ(B-V)	ΔV	Δ(V-R)	Δ(R-I)	Phase	Δ(B-V)	ΔV	Δ(V-R)	Δ(R-I)
0.00	0.071	-2.329	0.056	0.053	0.50	0.070	-2.362	0.064	0.047
0.01	0.070	-2.330	0.048	0.060	0.51	0.074	-2.367	0.054	0.047
0.02	0.064	-2.326	0.044	0.057	0.52	0.080	-2.373	0.047	0.062
0.03	0.080	-2.355	0.019	0.074	0.53	0.082	-2.376	0.048	0.055
0.04	0.075	-2.361	0.028	0.061	0.54	0.075	-2.377	0.053	0.048
0.05	0.053	-2.350	0.039	0.065	0.55	0.084	-2.393	0.043	0.054
0.06	0.068	-2.373	0.037	0.068	0.56	0.077	-2.397	0.047	0.056
0.07	0.066	-2.389	0.044	0.064	0.57	0.074	-2.402	0.056	0.047
0.08	0.058	-2.396	0.026	0.069	0.58	0.071	-2.402	0.046	0.068
0.09	0.076	-2.412	0.030	0.056	0.59	0.067	-2.406	0.062	0.066
0.10	0.073	-2.396	0.056	0.055	0.60	0.087	-2.411	0.046	0.060
0.11	0.092	-2.413	0.047	0.037	0.61	0.088	-2.414	0.051	0.053
0.12	0.065	-2.395	0.058	0.072	0.62	0.074	-2.421	0.054	0.050
0.13	0.119	-2.466	0.006	0.033	0.63	0.066	-2.434	0.053	0.048
0.14	0.085	-2.439	0.046	0.040	0.64	0.081	-2.446	0.028	0.057
0.15	0.075	-2.422	0.064	0.041	0.65	0.075	-2.442	0.041	0.060
0.16	0.096	-2.438	0.067	0.017	0.66	0.100	-2.470	0.018	0.058
0.17	0.078	-2.438	0.027	0.071	0.67	0.038	-2.442	0.067	0.047
0.18	0.074	-2.450	0.044	0.057	0.68	0.085	-2.472	0.029	0.053
0.19	0.045	-2.440	0.081	0.056	0.69	0.056	-2.444	0.045	0.057
0.20	0.072	-2.436	0.077	0.070	0.70	0.081	-2.463	0.038	0.057
0.21	0.073	-2.462	0.050	0.074	0.71	0.082	-2.475	0.029	0.063
0.22	0.066	-2.450	0.048	0.068	0.72	0.053	-2.461	0.044	0.048
0.23	0.081	-2.465	0.054	0.043	0.73	0.071	-2.466	0.032	0.073
0.24	0.082	-2.471	0.062	0.029	0.74	0.073	-2.470	0.054	0.044
0.25	0.079	-2.468	0.039	0.061	0.75	0.081	-2.478	0.037	0.047
0.26	0.087	-2.479	0.049	0.037	0.76	0.070	-2.467	0.054	0.043
0.27	0.091	-2.476	0.055	0.035	0.77	0.071	-2.469	0.038	0.055
0.28	0.078	-2.467	0.046	0.057	0.78	0.074	-2.475	0.036	0.060
0.29	0.078	-2.465	0.038	0.064	0.79	0.066	-2.462	0.052	0.046
0.30	0.085	-2.471	0.041	0.053	0.80	0.080	-2.471	0.036	0.053
0.31	0.084	-2.458	0.041	0.071	0.81	0.066	-2.461	0.035	0.060
0.32	0.088	-2.465	0.045	0.056	0.82	0.077	-2.467	0.030	0.062
0.33	0.081	-2.455	0.062	0.040	0.83	0.085	-2.462	0.021	0.071
0.34	0.085	-2.447	0.053	0.062	0.84	0.079	-2.452	0.026	0.063
0.35	0.075	-2.440	0.046	0.056	0.85	0.082	-2.447	0.036	0.056
0.36	0.085	-2.441	0.061	0.030	0.86	0.083	-2.453	0.020	0.065
0.37	0.076	-2.425	0.048	0.058	0.87	0.060	-2.445	0.022	0.063
0.38	0.083	-2.422	0.050	0.056	0.88	0.058	-2.427	0.025	0.079
0.39	0.091	-2.425	0.053	0.041	0.89	0.085	-2.440	0.006	0.064
0.40	0.077	-2.415	0.061	0.039	0.90	0.082	-2.420	0.009	0.078
0.41	0.073	-2.406	0.055	0.056	0.91	0.075	-2.408	0.014	0.075
0.42	0.072	-2.399	0.056	0.048	0.92	0.073	-2.397	0.002	0.082
0.43	0.083	-2.403	0.047	0.052	0.93	0.074	-2.380	0.040	0.057
0.44	0.078	-2.393	0.046	0.058	0.94	0.070	-2.377	0.034	0.061
0.45	0.075	-2.383	0.063	0.047	0.95	0.078	-2.376	0.023	0.060
0.46	0.081	-2.379	0.044	0.062	0.96	0.069	-2.363	0.026	0.073
0.47	0.080	-2.375	0.050	0.052	0.97	0.088	-2.354	0.032	0.054
0.48	0.071	-2.364	0.064	0.044	0.98	0.076	-2.340	0.042	0.054
0.49	0.078	-2.370	0.049	0.050	0.99	0.075	-2.333	0.035	0.071

Table 5: V497 Cep normal light-curves data for 2008

Phase	ΔB	ΔV	ΔR	ΔI	Phase	ΔB	ΔV	ΔR	ΔI
0.000	-0.337	-0.346	-0.360	-0.354	0.500	-0.364	-0.353	-0.369	-0.377
0.025	-0.350	-0.350	-0.364	-0.363	0.525	-0.349	-0.363	-0.360	-0.371
0.050	-0.345	-0.347	-0.358	-0.360	0.550	-0.352	-0.369	-0.366	-0.371
0.075	-0.354	-0.362	-0.368	-0.370	0.575	-0.363	-0.369	-0.374	-0.375
0.100	-0.359	-0.373	-0.370	-0.384	0.600	-0.373	-0.374	-0.383	-0.384
0.125	-0.374	-0.375	-0.374	-0.377	0.625	-0.376	-0.382	-0.388	-0.385
0.150	-0.368	-0.381	-0.372	-0.383	0.650	-0.383	-0.392	-0.396	-0.394
0.175	-0.390	-0.406	-0.389	-0.396	0.675	-0.385	-0.385	-0.397	-0.398
0.200	-0.390	-0.384	-0.390	-0.395	0.700	-0.388	-0.403	-0.401	-0.404
0.225	-0.393	-0.391	-0.396	-0.396	0.725	-0.391	-0.400	-0.400	-0.407
0.250	-0.379	-0.386	-0.392	-0.396	0.750	-0.382	-0.391	-0.394	-0.395
0.275	-0.382	-0.384	-0.389	-0.392	0.775	-0.376	-0.381	-0.389	-0.394
0.300	-0.374	-0.375	-0.376	-0.381	0.800	-0.371	-0.377	-0.382	-0.388
0.325	-0.370	-0.373	-0.379	-0.376	0.825	-0.367	-0.370	-0.375	-0.381
0.350	-0.360	-0.374	-0.371	-0.372	0.850	-0.360	-0.365	-0.371	-0.374
0.375	-0.359	-0.364	-0.377	-0.366	0.875	-0.348	-0.352	-0.363	-0.364
0.400	-0.353	-0.360	-0.359	-0.366	0.900	-0.339	-0.344	-0.342	-0.370
0.425	-0.348	-0.352	-0.353	-0.363	0.925	-0.333	-0.334	-0.347	-0.353
0.450	-0.334	-0.336	-0.348	-0.342	0.950	-0.315	-0.326	-0.334	-0.339
0.475	-0.348	-0.343	-0.346	-0.352	0.975	-0.322	-0.330	-0.323	-0.344

Table 6: V497 Cep normal color-curves for 2008

Phase	Δ(B-V)	ΔV	Δ(V-R)	Δ(R-I)	Phase	Δ(B-V)	ΔV	Δ(V-R)	Δ(R-I)
0.000	0.009	-0.346	0.014	-0.006	0.500	-0.011	-0.353	0.016	0.008
0.025	0.000	-0.350	0.014	-0.001	0.525	0.014	-0.363	-0.003	0.011
0.050	0.002	-0.347	0.011	0.002	0.550	0.017	-0.369	-0.003	0.005
0.075	0.008	-0.362	0.006	0.002	0.575	0.006	-0.369	0.005	0.001
0.100	0.014	-0.373	-0.003	0.014	0.600	0.001	-0.374	0.009	0.001
0.125	0.001	-0.375	-0.001	0.003	0.625	0.006	-0.382	0.006	-0.003
0.150	0.013	-0.381	-0.009	0.011	0.650	0.009	-0.392	0.004	-0.002
0.175	0.016	-0.406	-0.017	0.007	0.675	0.000	-0.385	0.012	0.001
0.200	-0.006	-0.384	0.006	0.005	0.700	0.015	-0.403	-0.002	0.003
0.225	-0.002	-0.391	0.005	0.000	0.725	0.009	-0.400	0.000	0.007
0.250	0.007	-0.386	0.006	0.004	0.750	0.009	-0.391	0.003	0.001
0.275	0.002	-0.384	0.005	0.003	0.775	0.005	-0.381	0.008	0.005
0.300	0.001	-0.375	0.001	0.005	0.800	0.006	-0.377	0.005	0.006
0.325	0.003	-0.373	0.006	-0.003	0.825	0.003	-0.370	0.005	0.006
0.350	0.014	-0.374	-0.003	0.001	0.850	0.005	-0.365	0.006	0.003
0.375	0.005	-0.364	0.013	-0.011	0.875	0.004	-0.352	0.011	0.001
0.400	0.007	-0.360	-0.001	0.007	0.900	0.005	-0.344	-0.002	0.028
0.425	0.004	-0.352	0.001	0.010	0.925	0.001	-0.334	0.013	0.006
0.450	0.002	-0.336	0.012	-0.006	0.950	0.011	-0.326	0.008	0.005
0.475	-0.005	-0.343	0.003	0.006	0.975	0.008	-0.330	-0.007	0.021

Table 7: EM Cep Maidanak observations (1987)

JD Hel. 2447060+	ΔV	JD Hel. 2447060+	ΔV	JD Hel. 2447060+	ΔV	JD Hel. 2447060+	ΔV
3.2971	-0.903	4.3076	-0.823	5.3020	-0.908	6.2819	-0.799
3.3032	-0.935	4.3117	-0.821	5.3062	-0.944	6.2860	-0.771
3.3082	-0.917	4.3159	-0.834	5.3093	-0.932	6.2902	-0.791
3.3157	-0.908	4.3249	-0.840	5.3149	-0.913	6.2944	-0.759
3.3192	-0.888	4.3291	-0.830	5.3190	-0.924	6.2978	-0.768
3.3219	-0.901	4.3416	-0.832	5.3232	-0.918	6.3020	-0.782
3.3254	-0.880	4.3464	-0.855	5.3277	-0.885	6.3062	-0.771
3.3372	-0.852	4.3534	-0.853	5.3319	-0.908	6.3096	-0.752
3.3403	-0.877	4.3583	-0.857	5.3360	-0.867	6.3131	-0.736
3.3437	-0.869	4.3631	-0.846	5.3402	-0.876	6.3173	-0.772
3.3464	-0.871	4.3673	-0.911	5.3451	-0.908	6.3214	-0.773
3.3492	-0.854	4.3733	-0.879	5.3492	-0.901	6.3253	-0.795
3.3525	-0.848	4.3774	-0.883	5.3534	-0.910	6.3291	-0.793
3.3553	-0.860	4.3819	-0.890	5.3576	-0.874	6.3339	-0.793
3.3581	-0.863	4.3964	-0.878	5.3617	-0.894	6.3464	-0.788
3.3610	-0.890	4.4009	-0.902	5.3656	-0.935	6.3503	-0.832
3.3663	-0.875	4.4048	-0.902	5.3770	-0.901	6.3541	-0.820
3.3690	-0.854	4.4089	-0.899	5.3816	-0.892	6.3576	-0.816
3.3720	-0.852	4.4131	-0.895	5.3863	-0.876	6.3617	-0.821
3.3746	-0.855	4.4173	-0.887	5.3909	-0.877	6.3652	-0.849
3.3777	-0.854	4.4214	-0.902	5.3951	-0.875	6.3694	-0.846
3.3812	-0.841	4.4263	-0.916	5.3999	-0.888	6.3732	-0.846
3.3844	-0.851	4.4381	-0.890	5.4041	-0.882	6.3774	-0.830
3.3942	-0.851	4.4423	-0.926	5.4083	-0.840	6.3812	-0.851
3.3984	-0.858	4.4471	-0.944	5.4131	-0.823	6.3850	-0.852
3.4013	-0.854	4.4527	-0.898	5.4197	-0.850	6.3888	-0.865
3.4052	-0.868	4.4569	-0.920	5.4250	-0.860	6.3971	-0.876
3.4083	-0.837	4.4603	-0.923	5.4284	-0.869	6.4006	-0.879
3.4111	-0.846	4.4680	-0.912	5.4333	-0.839	6.4048	-0.891
3.4144	-0.826	4.4735	-0.895	5.4377	-0.835	6.4086	-0.876
3.4170	-0.859	4.4777	-0.922	5.4416	-0.841	6.4131	-0.888
3.4201	-0.869	4.4839	-0.918	5.4458	-0.814	6.4173	-0.872
3.4228	-0.808	4.4895	-0.885	5.4503	-0.839	6.4214	-0.887
3.4254	-0.847	4.4951	-0.894	5.4544	-0.840	6.4256	-0.892
3.4435	-0.809			5.4583	-0.827	6.4298	-0.904
3.4470	-0.807			5.4624	-0.834	6.4339	-0.896
3.4499	-0.819			5.4686	-0.818	6.4381	-0.897
3.4533	-0.802			5.4708	-0.807	6.4471	-0.905
3.4561	-0.833			5.4749	-0.801	6.4513	-0.892
3.4602	-0.819			5.4791	-0.798	6.4555	-0.898
3.4629	-0.793			5.4833	-0.819	6.4590	-0.905
3.4659	-0.795			5.4892	-0.790	6.4635	-0.906
3.4687	-0.816			5.4930	-0.811	6.4677	-0.912
3.4756	-0.798					6.4714	-0.899
3.4798	-0.812					6.4756	-0.898
3.4832	-0.797					6.4795	-0.891
3.4852	-0.814					6.4839	-0.893
3.4888	-0.802					6.4881	-0.926
3.4921	-0.787					6.4934	-0.912
3.4957	-0.820					6.4985	-0.913
3.4984	-0.785					6.5034	-0.900
3.5026	-0.821						

Table 8: EM Cep Maidanak light-curve data 1987

Phase	ΔV	Phase	ΔV	Phase	ΔV	Phase	ΔV
0.000578	-0.768	0.243203	-0.912	0.491325	-0.816	0.769190	0.000
0.002294	-0.811	0.249529	-0.913	0.499884	-0.798	0.770584	-0.944
0.005788	-0.782	0.255607	-0.900	0.505094	-0.812	0.774430	-0.932
0.010998	-0.771	0.278470	-0.903	0.509311	-0.797	0.781376	-0.913
0.015215	-0.752	0.286037	-0.935	0.511792	-0.814	0.786462	-0.924
0.019556	-0.736	0.292239	-0.917	0.516257	-0.802	0.791671	-0.918
0.024766	-0.772	0.301542	-0.908	0.520351	-0.787	0.797253	-0.885
0.029852	-0.773	0.305883	-0.888	0.524816	-0.820	0.802463	-0.908
0.034689	-0.795	0.309233	-0.901	0.528165	-0.785	0.807549	-0.867
0.039403	-0.793	0.313574	-0.880	0.531908	-0.823	0.812758	-0.876
0.045357	-0.793	0.328211	-0.852	0.533375	-0.821	0.818836	-0.908
0.060862	-0.788	0.332056	-0.877	0.536993	-0.821	0.823922	-0.901
0.065700	-0.832	0.336274	-0.869	0.542203	-0.834	0.829132	-0.910
0.070413	-0.820	0.339623	-0.871	0.553367	-0.840	0.834342	-0.874
0.074755	-0.816	0.343096	-0.854	0.558577	-0.830	0.839427	-0.894
0.079840	-0.821	0.347189	-0.848	0.574082	-0.832	0.844265	-0.935
0.084182	-0.849	0.350662	-0.860	0.580036	-0.855	0.858406	-0.901
0.089392	-0.846	0.354135	-0.863	0.588719	-0.853	0.864111	-0.892
0.094105	-0.846	0.357733	-0.890	0.594797	-0.857	0.869941	-0.876
0.099315	-0.830	0.364307	-0.875	0.600751	-0.846	0.875647	-0.877
0.104028	-0.851	0.367656	-0.854	0.605960	-0.911	0.880857	-0.875
0.108742	-0.852	0.371377	-0.852	0.613403	-0.879	0.886811	-0.888
0.113456	-0.865	0.374602	-0.855	0.618489	-0.883	0.892021	-0.882
0.123751	-0.876	0.378448	-0.854	0.624070	-0.890	0.897231	-0.840
0.128093	-0.879	0.382789	-0.841	0.642056	-0.878	0.903185	-0.823
0.133302	-0.891	0.386758	-0.851	0.647638	-0.902	0.911371	-0.850
0.138016	-0.876	0.398914	-0.851	0.652476	-0.902	0.917945	-0.860
0.143598	-0.888	0.404124	-0.858	0.657562	-0.899	0.922163	-0.869
0.148807	-0.872	0.407721	-0.854	0.662771	-0.895	0.928241	-0.839
0.153893	-0.887	0.412559	-0.868	0.667981	-0.887	0.933699	-0.835
0.159103	-0.892	0.416404	-0.837	0.673067	-0.902	0.938536	-0.841
0.164313	-0.904	0.419877	-0.846	0.679145	-0.916	0.943746	-0.814
0.169398	-0.896	0.423971	-0.826	0.693782	-0.890	0.949328	-0.839
0.174608	-0.897	0.427196	-0.859	0.698991	-0.926	0.954414	-0.840
0.185772	-0.905	0.431041	-0.869	0.704945	-0.944	0.959251	-0.827
0.190981	-0.892	0.434390	-0.808	0.711892	-0.898	0.964337	-0.834
0.196191	-0.898	0.437615	-0.847	0.717101	-0.920	0.972027	-0.818
0.200533	-0.905	0.460067	-0.809	0.721319	-0.923	0.974756	-0.807
0.206114	-0.906	0.464408	-0.807	0.730870	-0.912	0.979842	-0.801
0.211324	-0.912	0.468005	-0.819	0.737692	-0.895	0.980855	-0.799
0.215914	-0.899	0.472223	-0.802	0.742902	-0.922	0.985052	-0.798
0.221123	-0.898	0.475696	-0.833	0.750593	-0.918	0.985941	-0.771
0.225961	-0.891	0.480782	-0.819	0.757539	-0.885	0.990262	-0.819
0.231419	-0.893	0.484131	-0.793	0.764485	-0.894	0.991151	-0.791
0.236629	-0.926	0.487852	-0.795	0.765375	-0.908	0.996361	-0.759
						0.997580	-0.790

Table 9: EM Cep Tallinn light-curve data 2001

Phase	ΔV	Phase	ΔV
0.46278	-0.882	0.61312	-0.938
0.46538	-0.878	0.61572	-0.939
0.46799	-0.887	0.62143	-0.935
0.47059	-0.885	0.62589	-0.950
0.47320	-0.882	0.62875	-0.957
0.47791	-0.876	0.63445	-0.947
0.48052	-0.873	0.63706	-0.949
0.48312	-0.876	0.63966	-0.950
0.49069	-0.867	0.64227	-0.953
0.49329	-0.862	0.64487	-0.960
0.49590	-0.859	0.64921	-0.963
0.49850	-0.866	0.65182	-0.958
0.50111	-0.860	0.65603	-0.968
0.50619	-0.855	0.66559	-0.966
0.50904	-0.861	0.66819	-0.975
0.51165	-0.865	0.67080	-0.978
0.51475	-0.868	0.67663	-0.975
0.51946	-0.872	0.67923	-0.971
0.52232	-0.859	0.68183	-0.978
0.53621	-0.876	0.68444	-0.977
0.53881	-0.874	0.68704	-0.982
0.54142	-0.880	0.69201	-0.981
0.54402	-0.887	0.69461	-0.981
0.54886	-0.880	0.69722	-0.982
0.55147	-0.881	0.69982	-0.987
0.55407	-0.890	0.70689	-0.986
0.55668	-0.893	0.70937	-0.982
0.55928	-0.895	0.71198	-0.982
0.56400	-0.897	0.71471	-0.987
0.56660	-0.904	0.71719	-0.989
0.56921	-0.896	0.72215	-0.986
0.57181	-0.903	0.72475	-0.976
0.57690	-0.898	0.72736	-0.972
0.57950	-0.902	0.73133	-0.982
0.58211	-0.910	0.73641	-0.977
0.58471	-0.916	0.74262	-0.977
0.58756	-0.917	0.74522	-0.979
0.59277	-0.909	0.76680	-0.970
0.59538	-0.918	0.77970	-0.970
0.59798	-0.928	0.78467	-0.971
0.60059	-0.934	0.78950	-0.964
0.60679	-0.930	0.79422	-0.971
0.61001	-0.927	0.80216	-0.964

Tagakaane foto: „Leivatehas“ Maidanakis