T Monocerotis

A well known classical cepheid with a variable period.
I compile 209 maximum times from the 1870ies until 2004
and give a revised ephemeris.

(Ralf Meyer, Germany)

US astronomer Benjamin Apthorp GOULD discovered the variability of T Monocerotis in Cordoba, Argentina (GOULD, 1872). The Moscow GCVS (1988/2005) reports a classical cepheid (DCEP), a brightness variation between 5,58 and 6,62 mag(V) and a period of about 27 days.

Since 1920 researchers noticed, that the period of T Mon is variable (for example BEMPORAD, 1921 or NIELSEN, 1930). SZABADOS (1981) derived quadratic elements and demonstrated the systematic behaviour of higher order residuals. I collected 209 times of maximum and plotted an O-C-diagram (figure 2 und 3). The appendix at the end of this paper gives details of each entry. I calculated O-C-values with the revised ephemeris given below. The global diagram shows a general period increase, complicated by superimposed waves. Figure 3 is a close-up, covering the years 1960 until 2004. In the 1980ies the period increase accelerated considerably. I took 6 photoelectric maximum times of the years 1988 until 2004, which approximately followed a straight line, applied a linear fit and derived the following revised elements:

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JD(max)  =  2447269,9  +  27,035  *  E     (Meyer R., this paper)
            ±       5          2
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Figure 1 shows the photoelectric data of Moffett & Barnes (reference in the appendix) of the years 1977 until 1979 before the adopted time interval. The set already is slightly out of phase.

I divided my data set into a premium quality part (weight 1, blue in the diagrams) and a mean quality part (weight 0, yellow). All photoelectric observations are premium quality, others only on certain conditions (see key to the appendix at the end of the paper). The first photoelectric observation dates from 1948/49. There are only few photographic and visual observations with the polarizing or extinction photometers typical for professional work until 1940. The vast majority of data points before 1950 (epoch –500) therefore has been won visually with a small telescope and no further technical equipment. Comparing the parts of the global diagram before and after epoch –500, the poor quality of modern visual amateur observations strikes. I suppose two reasons for the inacceptable bias to positive O-C-values: 1. Too few data points result in bad definition of the rise to maximum light. 2. Cursory procedures to find the maximum generally undervalue the asymmetry of the lightcurve and produce belated times.

References:

BEMPORAD Az., 1921	Mem.Soc.Astron.Ital. 1, 229
GCVS (KHOLOPOV ea 1988)	Gen.Cat.of Var.Stars Vol.4 <<http://www.sai.msu.su/groups/cluster/gcvs/gcvs/iii/>>
GOULD Benj.Apth., 1872	Amer.J.Science 4(3), 477
NIELSEN Ax., 1930	Astron.Nachr. 217, 239
SZABADOS L., 1981	Comm.Konkoly Observ.Hung.Acad.Sci., Budapest Nr. 77

Ralf Meyer, Fürnheim 16
D-91717 Wassertrüdingen, Germany

Figure 1 – photoelectric lightcurve (Moffett & Barnes, 1977...79):

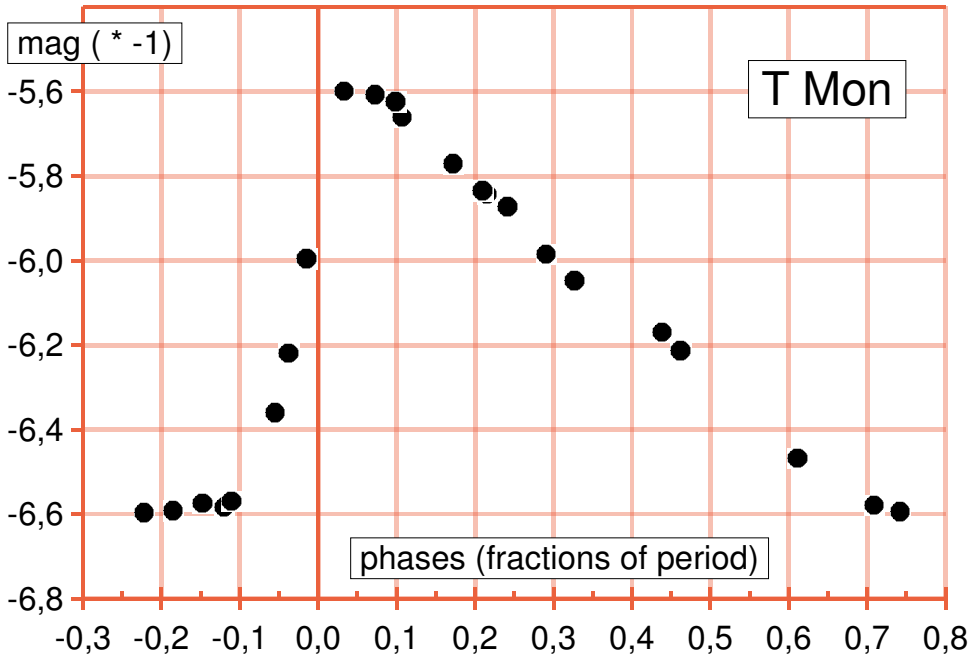


Figure 2 – global O-C-diagram (1872 .... 2004):

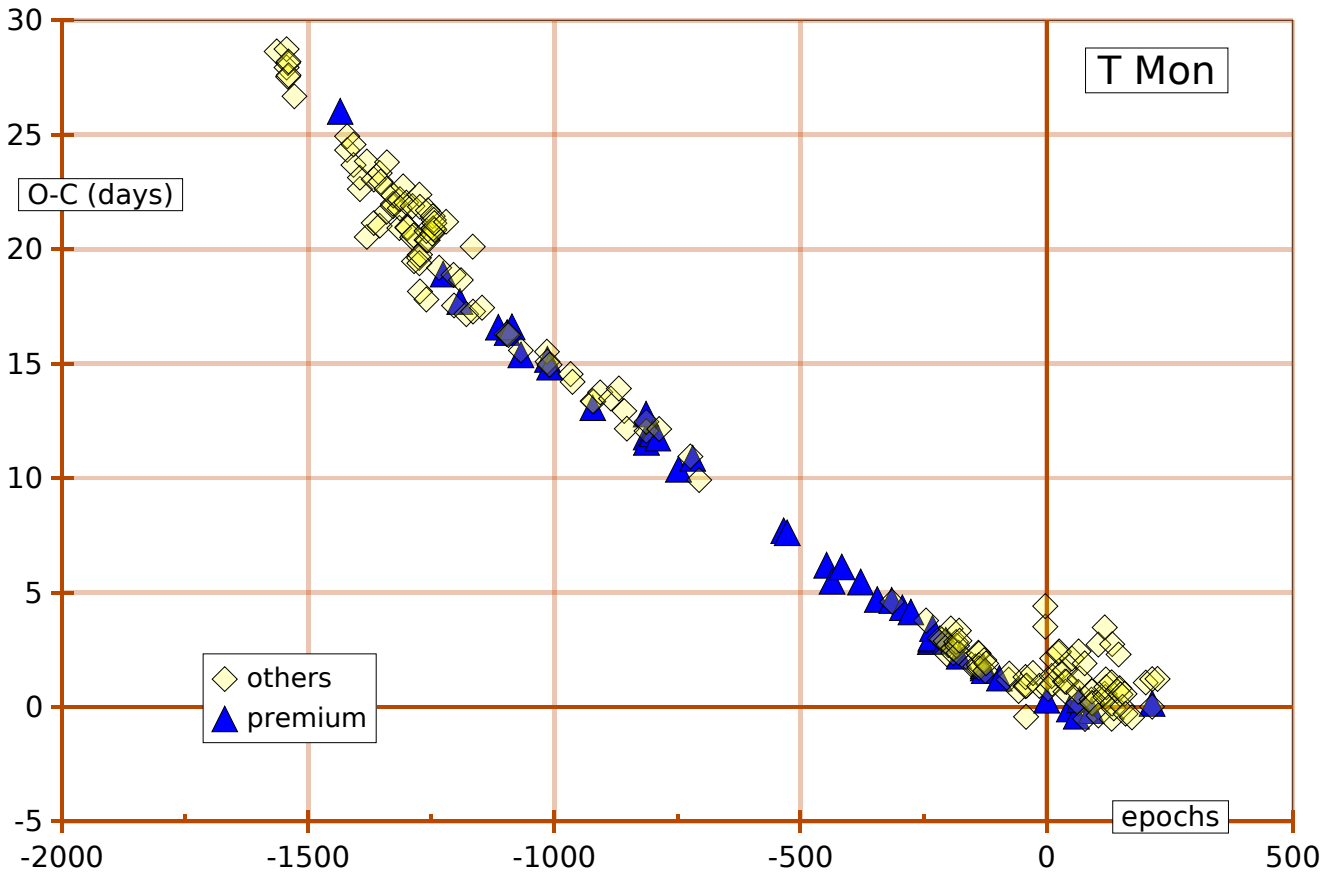
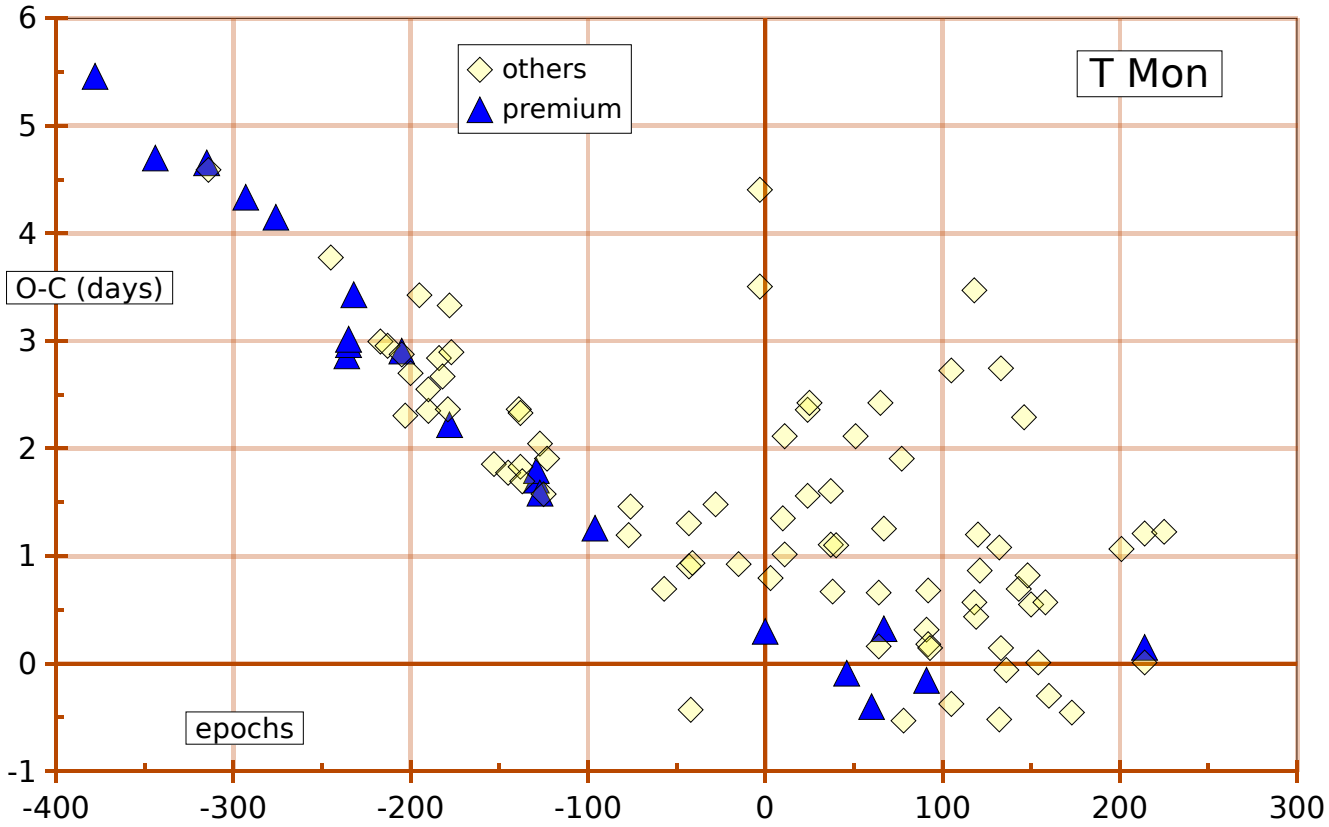


Figure 3 – O-C-diagram close-up (1960 .... 2004):



Appendix - details of reported maximum times:

1	2	3	4	5	6	7	8
NR	JD	O	X	W	REPORTING OBSERVERS	REFERRING AUTHORS	REFERENCE
1	05015,8	VS			URANOM ARGENTINA	MUELLER&HARTWIG SZABADO	KONK 77
2	05555,8	VS			URANOM ARGENTINA	MUELLER&HARTWIG SZABADO	KONK 77
3	05556,6	VS			DAVIS (DUDLEY OBS)	SANFORD SZABADOS	KONK 77
4	05636,5	VS	MN		SCHOENFELD		AN 87 1
5	05637,1	VS	MX		SCHOENFELD		AN 87 1
6	05663,6	VS	MA		SCHOENFELD		AN 87 1
7	05664,2	VS			SCHOENFELD		AN 87 1
8	05987,1	VS			SCHOENFELD	NIELSEN	AN 239 217
9	08500,7	VS	L	1	SAWYER		AN 105 327
10	08877,5	VS	MN		SAWYER		AN 111 305
11	08878,1	VS	MX		SAWYER		AN 111 305
12	09228,3	VS	MN		SAWYER		AN 111 305
13	09229,2	VS	MX		SAWYER		AN 111 305
14	09578,7	VS	MN		SAWYER		AJ 7 49
15	09579,2	VS	MX		SAWYER		AJ 7 49
16	09955,1	VS	MN		SAWYER		AJ 7 109
17	09958,4	VS	MX		SAWYER		AJ 7 109
18	10334,2	VS	MN		SAWYER		AJ 8 63
19	10336,1	VS	MX		SAWYER		AJ 8 63

20	10658,5	VS	MN	SAWYER		AJ	8 41
21	10660,8	VS	MX	SAWYER		AJ	8 41
22	10714,5	VS		YENDELL	SZABADOS	KONK	77
23	11037,6	VS	MN	SAWYER		AJ	9 167
24	11038,6	VS		YENDELL	SZABADOS	KONK	77
25	11066,8	VS	MX	SAWYER		AJ	9 167
26	11389,3	VS	MN	SAWYER		AJ	10 86
27	11389,4	VS	MX	SAWYER		AJ	10 86
28	11416,8	VS		YENDELL	SZABADOS	KONK	77
29	11739,8	VS	MN	SAWYER		AJ	11 14
30	11767,7	VS	MX	SAWYER		AJ	11 14
31	11768,1	VS		YENDELL	SZABADOS	KONK	77
32	11957,9	VS		MARKWICK	SZABADOS	KONK	77
33	12119,4	VS		YENDELL	SZABADOS	KONK	77
34	12172,4	VS	MX	SAWYER		AJ	16 113
35	12199,4	VS	MN	SAWYER		AJ	16 113
36	12442,3	VS	MX	SAWYER		AJ	16 113
37	12470,7	VS		YENDELL	SZABADOS	KONK	77
38	12523,5	VS		YENDELL	NIELSEN	AN	239 217
39	12549,4	VS	MN	SAWYER		AJ	16 113
40	12819,9	VS	MX	SAWYER		AJ	16 113
41	12846,7	VS		PORRO	SZABADOS	KONK	77
42	12849,7	VS	MX	YENDELL		AJ	14 85
43	12872,5	VS	MN	YENDELL		AJ	14 85
44	12874,1	VS	MN	SAWYER		AJ	16 113
45	12876,2	VS		YENDELL	SZABADOS	KONK	77
46	13223,6	VS	MN	YENDELL		AJ	15 174
47	13226,2	VS		YENDELL	SZABADOS	KONK	77
48	13226,6	VS	MX	YENDELL		AJ	15 174
49	13307,3	VS	MN	SPERRA		AJ	15 109
50	13308,6	VS	MX	SPERRA		AJ	15 109
51	13550,9	VS	MN	YENDELL		AJ	17 67
52	13578,7	VS	MX	YENDELL		AJ	17 67
53	13605,2	VS		YENDELL	SZABADOS	KONK	77
54	13605,2	VS	MX	HISGEN		AN	143 251
55	13632,6	VS	MN	HISGEN		AN	143 251
56	13659,2	VS	MN	SPERRA		AJ	17 70
57	13659,5	VS	MX	SPERRA		AJ	17 70
58	13927,9	VS	MN	YENDELL		AJ	21 23
59	14143,9	VS	L 1	PICKERING		HA	46 127
60	14308,4	VS	MX	YENDELL		AJ	21 23
61	14711,6	VS	MX	LUIZET		AN	160 360
62	14737,3	VS	MN	LUIZET		AN	160 360
63	15061,9	VS	L 1	WENDELL		HA	69 42
64	15116,9	VS	MX	LUIZET		AN	160 360
65	15412,8	VS	MN	LUIZET		AN	160 360
66	15767,2	VS	MX	YENDELL		AJ	22 155
67	15791,4	VS	MN	YENDELL		AJ	22 155
68	16278,2	VS		WORSSELL	NIELSEN	AN	239 217
69	17169,5	VS	L 1	NIJLAND		UTRR	8 192
70	17628,8	VS		NIJLAND		UTRR	8
71	17655,9	VS	L 1	VON ZEIPEL		AN	177 379
72	17736,9	VS		MARKWICK	NIELSEN	AN	239 217
73	17926,5	VS	L 1	NIJLAND		UTRR	8 192
74	18411,9	VS	L 1	BEMPORAD		MSSI	39(1) 67
75	18412,1	VS		BEMPORAD		MSSI	39(1) 67
76	19844,9	VS		KAISER	SZABADOS	KONK	77
77	19871,5	PP		ROBINSON		HA	90 27

78	19871,6	PP	L	1	ROBINSON		HA	90	27	
79	19979,4	VS	L	1	DZIEWULSKI		WILNO	5	15	
80	19979,5	VS			DZIEWULSKI		WILNO	5	15	
81	21141,6	VS			LUYTEN	NIELSEN	AN	239	217	
82	21249,4	VS			DE ROY	NIELSEN	AN	239	217	
83	22356,7	VS	L	1	BEMPORAD		CNAP	1(17)	8	
84	22357,0	VS			BEMPORAD		CNAP	1(17)	8	
85	22384,0	VS			NN	BERDNIKOV EA	AVSJ	31	146	
86	22762,9	VS			GALLISOT	NIELSEN	AN	239	217	
87	23357,4	VS			BERNARD	NIELSEN	AN	239	217	
88	23790,4	VS			SANFORD	SZABADOS	KONK	77		
89	24086,8	VS			SCHULLER	NN SZABADOS	KONK	77		
90	24221,2	VS			AURINO	NIELSEN	AN	239	217	
91	25275,2	PP	L	1	HELLERICH		AN	256	221	
92	25276,2	VS	L	1	AHNERT		AN	237	121	
93	25302,0	VS	L	1	KUKARKIN		PSMO	13	118	
94	25302,5	PP			HELLERICH		AN	256	221	
95	25302,9	VS			LAUSE F		AN	264	229	
96	25626,8	VS	L	1	AHNERT		AN	237	121	
97	25924,0	VS	L	1	ZVEREV		PSMO	8(1)	125	
98	26005,5	VS			ZVEREV		PSMO	8(1)	53	
99	27058,1	VS	L	1	FLORYA&KUKARKIN		PSMO	23	1	
100	27707,5	VS			KREBS C		AN	257	113	
101	27842,6	VS	L	1	KREBS C		AN	257	113	
102	28193,1	VS			NIELSEN		AAR	16		
103	32840,91	LC		1	EGGEN	SZABADOS	KONK	77		
104	33030,06	LC	L	1	EGGEN		APJ	113	367	
105	35191,45	LC		1	IRWIN	SZABADOS	KONK	77		
106	35488,13	LC		1	WALRAVEN EA	SZABADOS	KONK	77		
107	36029,46	LC	L	1	MITCHELL EA		BOTT	3	153	
108	37056,13	LC		1	MITCHELL EA	SZABADOS	KONK	77		
109	37974,56	LC		1	WILLIAMS JOHN A	SZABADOS	KONK	77		
110	38758,53	LC		1	WISNIEWSKI&JOHNSON	SZABADOS	KONK	77		
111	38785,5	VS			NN	BERDNIKOV EA	AVSJ	31	146	
112	39352,98	LC		1	TAKASE	SZABADOS	KONK	77		
113	39812,39	LC		1	ABAFFY	SZABADOS	KONK	77		
114	40650,1	VS			NN	BERDNIKOV EA	AVSJ	31	146	
115	40892,50	LC	L	1	FELTZ&MCNAMARA		PASP	92	609	
116	40919,64	LC	L	1	PEL		AAPS	24	413	
117	40919,69	LC		1	PEL	SZABADOS	KONK	77		
118	41001,21	LC		1	EVANS	SZABADOS	KONK	77		
119	41406,3	VS			NN	BERDNIKOV EA	AVSJ	31	146	
120	41514,4	VS			CRAGG	SZABADOS	KONK	77		
121	41730,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	
122	41730,63	LC		1	LANDIS	SZABADOS	KONK	77		
123	41784,1	VS			NN	BERDNIKOV EA	AVSJ	31	146	
124	41865,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	
125	42001,5	VS			BOEHME	SZABADOS	KONK	77		
126	42135,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	
127	42135,8	VS			NN	BERDNIKOV EA	AVSJ	31	146	
128	42298,3	VS			BERDNIKOV	SZABADOS	KONK	77		
129	42352,2	VS			NN	BERDNIKOV EA	AVSJ	31	146	
130	42433,0	VS			NN	BERDNIKOV EA	AVSJ	31	146	
131	42459,89	LC	L	1	DEAN EA		MORAS	83	74	
132	42461,0	VS			NN	BERDNIKOV EA	AVSJ	31	146	
133	42487,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	
134	43135,4	VS			NN	BERDNIKOV EA	AVSJ	31	146	
135	43351,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	

136	43514,4	VS	MX		NN	BUSCH	MVS	8	78	
137	43540,9	VS			NN	BERDNIKOV EA	AVSJ	31	146	
138	43541,4	VS			BRANZKE	BUSCH SZABADOS	KONK	77		
139	43567,8	VS			NN	BERDNIKOV EA	AVSJ	31	146	
140	43784,09	LC	L	1	SZABADOS	MCMDB	KONK	77		
141	43784,18	LC		1	SZABADOS		KONK	77		
142	43838,04	LC	L	1	MOFFETT&BARNES	MCMDB	APJS	55	389	
143	43838,5	VS			RICHTER	BUSCH SZABADOS	KONK	77		
144	43892,1	VS			NN	BERDNIKOV EA	AVSJ	31	146	
145	43946,5	VS			NN	BERDNIKOV EA	AVSJ	31	146	
146	44675,80	LC	L	1	COULSON&CALDWELL	MCMDB	SAAOC	9	5	
147	45189,4	VS			NN	BERDNIKOV EA	AVSJ	31	146	
148	45216,7	VS			NN	BERDNIKOV EA	AVSJ	31	146	
149	45729,6	VS			NN	BERDNIKOV EA	AVSJ	31	146	
150	46108,3	VS			SCHMIDT JOACHIM		BAVM	39		
151	46108,7	VS			NN	BERDNIKOV EA	AVSJ	31	146	
152	46134,0	VS			THOMAS AX		BAVM	39		
153	46162,4	VS			NN	BERDNIKOV EA	AVSJ	31	146	
154	46514,4	VS			STURM		BAVM	43		
155	46865,3	VS			STURM		BAVM	46		
156	47192,3	VS			STURM		BAVM	50		
157	47193,2	VS			ALTEWEIER		BAVM	50		
158	47270,20	LC	L	1	BERDNIKOV (EA)	MCMDB	LOCI	DIV		
159	47351,8	VS			THOMAS AX		BAVM	60		
160	47541,6	VS			HASSFORTHER		BAVM	52		
161	47568,3	VS			STURM		BAVM	52		
162	47569,4	VS			KRIEBEL		BAVM	52		
163	47920,3	VS			STURM		BAVM	56		
164	47921,1	VS			KRIEBEL		BAVM	56		
165	47948,2	VS			DAHM		BAVM	59		
166	48271,3	VS			STURM		BAVM	59		
167	48271,8	VS			KRIEBEL		BAVM	59		
168	48297,9	VS			BAULE		BAVM	60		
169	48352,4	VS			DAHM		BAVM	60		
170	48513,42	LC	L	1	BERDNIKOV (EA)	MCMDB	LOCI	DIV		
171	48650,8	VS			KRIEBEL		BAVM	60		
172	48891,60	LC	L	1	BERDNIKOV (EA)	MCMDB	LOCI	DIV		
173	49000,3	VS			STURM		BAVM	62		
174	49000,8	VS			GOLDHAHN		BAVM	62		
175	49029,6	VS			RAETZ KERSTIN		BAVM	79		
176	49081,57	LC	L	1	ARELLANO FERRO EA		APJS	117	167	
177	49082,5	VS			DAHM		BAVM	68		
178	49353,5	VS			ENSKONATUS		BAVM	68		
179	49378,1	VS			STURM		BAVM	68		
180	49729,93	LC	L	1	BERDNIKOV (EA)	MCMDB	LOCI	DIV		
181	49730,4	VS			STURM		BAVM	79		
182	49757,3	VS			SCHUBERT		BAVM	79		
183	49757,8	VS			ENSKONATUS		BAVM	79		
184	49784,3	VS			SCHROEDER EL		BAVM	79		
185	50108,2	VS			ENSKONATUS		BAVM	93		
186	50111,3	VS			SCHUBERT		BAVM	93		
187	50460,6	VS			ENSKONATUS		BAVM	101		
188	50463,5	VS			SCHUBERT		BAVM	101		
189	50487,5	VS			NN	BERDNIKOV EA	AVSJ	31	146	
190	50515,3	VS			STURM		BAVM	101		
191	50542,0	VS			SCHUBERT		BAVM	101		
192	50838,0	VS			ENSKONATUS		BAVM	122		
193	50839,6	VS			MEYER R		BAVM	113		

194	50865,7	VS		NN	BERDNIKOV EA	AVSJ	31	146	
195	50868,3	VS		STURM		BAVM	113		
196	50946,6	VS		NN	BERDNIKOV EA	AVSJ	31	146	
197	51136,6	VS		NN	BERDNIKOV EA	AVSJ	31	146	
198	51219,3	VS		STURM		BAVM	122		
199	51271,9	VS		ENSKONATUS		BAVM	143		
200	51325,7	VS		NN	BERDNIKOV EA	AVSJ	31	146	
201	51433,3	VS		NN	BERDNIKOV EA	AVSJ	31	146	
202	51542,0	VS		ENSKONATUS		BAVM	143		
203	51595,2	VS		NN	BERDNIKOV EA	AVSJ	31	146	
204	51946,5	VS		MEYER R		BAVM	143		
205	52705,0	VS		STURM		BAVM	157		
206	53055,4	VS		MEYER R		BAVM	171		
207	53055,54	LC	L 1	ASAS 3 2006MAI29		062513+0705.1			
208	53056,6	VS		STURM		BAVM	171		
209	53354,0	VS		BISSON&DUMONT		GENC	1026	1	

Key to consecutive columns:

1: consecutive numbers of the entries
2: JD-2400000
3: method of observation, VS = visual including traditional photometers, PP = all kinds of photographies and plates, LC = photoelectric or CCD
4: way, how a maximum time was found: no entry = I (present paper) took a time given in a publication, but sometimes rounded to a smaller number of decimals
L = I took single observations from the publication and won an own maximum time
MA, MX, MN = I encountered a report of a minimum or maximum time based on few observations (typical for the 19th century) and transformed this report as good as possible into what we today regard as a reliable maximum time
5: weight (no entry or 1): all LC get weight; PP and VS get weight only on the condition, that I could derive an own maximum time from single observations reported by the observer; MA, MX and MN (see 4 above) and all modern amateur / visual communications of a simple maximum time get no weight.
6 until 8:
NN means, that the name of the oberserver has not been reported or that there were many different observers, who cannot be named in detail.
AAPS = Astronomy and Astrophysics Supplement Series, AJ = Astron. Journ., AN = Astron.Nachr., APJ = Astrophysical Journal, APJS = Astrophysical Journal Supplement Series, AVSJ = Journal of the AAVSO (USA), BAVM = BAV-Mitteilungen (Berlin, D), BOTT = Boletín de los Observatorios de Tonantzintla y Tacubaya (Puebla, Mexico), CNAP = Osservatorio Astronomico di Capodimonte-Napoli Contributi Astronomici (I), GENC = Note Circulaire GEOS (Paris, F), HA = Annals of the Harvard College Observatory (USA), KONK = Communications from the KONKOLY Observatory of the Hungarian Academy of Sciences (Budapest, H), MCMDB = loci diversi taken from the McMaster Cepheid Photometry ... Archive (http://crocus.physics.mcmaster.ca/Cepheid/), MORAS = Memoirs of the Royal Astronomical Society, MSSI = Memorie della Societá degli Spettroscopisti Italiani (Catania, I), MVS = Mitteilungen über Veränderliche Sterne (Sonneberg, Germany/GDR), PASP = Publications of the Astronomical Society of the Pacific, PSMO = Publications (Trudy) of the Sternberg Astronomical Institute/Observatory (Moscow, USSR), SAAOC = South African Astronomical Observatory Circulars, UTRR = Recherches Astronomiques de l' Observatoire d' Utrecht (NL), WILNO = Bulletin de l'Observatoire Astronomique de Vilno, Wilno-Bulletin (Poland).