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Physical studies of asteroids

XXXII. Rotation periods and *UBVRI*-colours for selected asteroids

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Abstract. We present lightcurves of selected asteroids. Most of the asteroids were included to obtain refined spin periods. Enhanced periods were determined for 11 Parthenope, 306 Unitas and 372 Palma. We confirmed the spin periods of 8 Flora, 13 Egeria, 71 Niobe, 233 Asterope, 291 Alice, 409 Aspasia, 435 Ella and 512 Taurinensis. We determined also *BV*-colours for most of the included asteroids and *UBVRI*-colours for a total of 22 asteroids.

Key words: minor planets — photometry

1. Introduction

We made the observations in order to improve spin periods and to measure lightcurve properties of some previously less well observed asteroids. This work is a continuing process and has been previously reviewed by Binzel et al. (1989) and Lagerkvist & Claesson (1996). The frequently updated version of a spin period table is available by `anonymous ftp` from `ftp.astro.uu.se` in the directory `pub/Asteroids/RotationPeriods`. The spin periods in this paper were determined with a method described by Magnusson et al. (1993). Accurate spin periods are needed in order to improve e.g. modelling of asteroid shapes. For some asteroids included in this paper, future observations from one more apparition may lead to a possibility to determine the spin vector. We also give improved periods for some asteroids and confirm some other periods.

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Partly based on observations from the European Southern Observatory, La Silla, Chile.

We also measured *UBVRI*-colours for most of the asteroids. This work is complementary to the spectroscopy, e.g. by Gaffey & McCord (1979), and narrow-band photometry, e.g. by Chapman & Gaffey (1979). We encourage future asteroid observers to include also *UBVRI*-observations if the filters are available.

2. Observations

We made the observations with the 50 cm ESO-telescope and 61 cm Bochum Telescope (AE, JP, AN, MG) at La Silla, Chile. The instrumentation included a normal *UBVRI*-photometer and a DLR MkII CCD-camera. Other observations were accomplished at the 0.6 m Swedish telescope (TO) at La Palma, Canary Islands, the Kvistaberg 1–m Schmidt–telescope (TO), Siding Springs 1-m telescope (PM) and the 70–cm telescope of Kharkov Observatory. The observations at La Silla were made mostly in *B* and *V* bands and *UBVRI* colours were measured occasionally to obtain colour indices for the observed asteroids. The observations at La Palma were made in the the *B* and *V* bands only. The reductions of the La Silla observations were done with a modified Snopy (ESO) and ASTPHOT (DLR) programs. All the data were finally corrected for non–linearities caused by observations during twilight.

3. Results

The aspect data for the observed asteroids may be found in Tables 1–2. The lightcurves of individual asteroids are presented in Figs. 1–18. In the composite lightcurves the individual nights of observations are shifted in magnitude for optimum fit using the method described by Magnusson & Lagerkvist (1990). The actual shifts are given in the

Table 1. Aspect data

Asteroid	Date (UT)	r AU	Δ AU	α deg	λ 2000.0	β 2000.0	Tel/Inst	Observer
8 Flora	1986 Apr. 18.6	2.5221	1.5542	7.8	191.0	9.6	SiS/1−m	PM
8 Flora	1993 May 11.2	2.5020	1.5275	7.8	248.9	7.4	ESO/61−cm	AE
8 Flora	1993 May 13.2	2.5004	1.5179	7.0	248.4	7.4	ESO/61−cm	AE
8 Flora	1993 May 14.2	2.4996	1.5135	6.5	248.2	7.3	ESO/61−cm	AE
8 Flora	1993 May 17.2	2.4972	1.5018	5.3	247.4	7.3	ESO/61−cm	AE
8 Flora	1993 May 18.2	2.4964	1.4968	4.9	247.2	7.3	ESO/61−cm	AE
8 Flora	1993 May 21.2	2.4939	1.4901	3.9	246.4	7.2	ESO/61−cm	AE
11 Parthenope	1995 Feb. 2.9	2.6938	1.7093	1.2	130.4	0.7	KVI/1−m	TO
11 Parthenope	1995 Feb. 7.9	2.6946	1.7170	3.5	129.2	0.9	KVI/1−m	TO
11 Parthenope	1995 Mar. 31.9	2.6969	2.1467	20.0	123.6	1.8	KVI/1−m	TO
11 Parthenope	1995 Apr. 1.9	2.6968	2.1590	20.1	123.7	1.8	KVI/1−m	TO
11 Parthenope	1995 Apr. 3.9	2.6967	2.1839	20.4	123.9	1.8	KVI/1−m	TO
11 Parthenope	1995 Apr. 4.9	2.6966	2.1965	20.5	123.9	1.8	KVI/1−m	TO
13 Egeria	1995 Dec. 12.0	2.4351	1.2155	8.8	60.3	11.5	LaP/60−cm	TO
13 Egeria	1995 Dec. 28.0	2.4231	1.5862	15.1	57.5	12.5	LaP/60−cm	TO
13 Egeria	1995 Dec. 29.0	2.4224	1.5937	15.5	57.3	12.5	LaP/60−cm	TO
13 Egeria	1996 Jan. 18.0	2.4084	1.7775	21.0	56.6	12.9	LaP/60−cm	TO
13 Egeria	1996 Feb. 1.0	2.3994	1.9322	23.2	57.9	12.9	LaP/60−cm	TO
13 Egeria	1997 Feb. 4.1	2.4539	2.0045	22.8	209.1	12.4	KHA/70−cm	FV
14 Irene	1994 Oct. 23.3	2.9831	2.0197	5.8	16.3	−12.3	ESO/50−cm	JP
25 Phocaea	1995 Sep. 18.2	2.0917	1.2548	19.8	38.8	9.8	ESO/50−cm	JP
25 Phocaea	1995 Sep. 19.2	2.0945	1.2595	19.3	38.6	9.7	ESO/50−cm	JP
25 Phocaea	1995 Sep. 20.2	2.0973	1.2444	18.9	38.5	9.6	ESO/50−cm	JP
64 Angelina	1995 Sep. 22.2	2.7581	1.8490	10.8	29.8	1.8	ESO/50−cm	JP
64 Angelina	1995 Sep. 24.2	2.7556	1.8337	8.6	28.8	1.9	ESO/50−cm	JP
64 Angelina	1995 Sep. 29.2	2.7493	1.7994	8.2	28.6	1.9	ESO/50−cm	JP
71 Niobe	1993 May 11.3	2.3232	1.5579	19.9	274.0	− 31.0	ESO/61−cm	AE
71 Niobe	1993 May 14.3	2.3261	1.5391	19.3	273.8	− 31.9	ESO/61−cm	AE
71 Niobe	1993 May 16.3	2.3280	1.5273	18.9	273.6	− 32.0	ESO/61−cm	AE
71 Niobe	1993 May 17.3	2.3290	1.5217	18.6	273.4	− 32.0	ESO/61−cm	AE
71 Niobe	1994 Sep. 21.8	3.1016	2.1670	8.1	4.8	25.1	KVI/1−m	TO
71 Niobe	1994 Oct. 3.9	3.1148	2.1907	8.4	1.3	25.8	KVI/1−m	TO
71 Niobe	1994 Oct. 5.9	3.1169	2.1984	8.7	1.3	25.8	KVI/1−m	TO
71 Niobe	1994 Oct. 10.1	3.1213	2.2179	9.3	0.3	25.9	KVI/1−m	TO
71 Niobe	1994 Oct. 25.1	3.1363	2.3229	12.2	357.3	25.6	KVI/1−m	TO
110 Lydia	1993 May 13.4	2.6440	1.9503	18.6	289.3	− 4.5	ESO/61−cm	AE
114 Kassandra	1993 May 13.4	2.7213	1.9015	14.9	276.2	7.0	ESO/61−cm	AE
114 Kassandra	1993 May 15.4	2.7242	1.8862	14.3	276.0	7.1	ESO/61−cm	AE
114 Kassandra	1993 May 18.3	2.7283	1.8655	13.4	275.7	7.2	ESO/61−cm	AE
114 Kassandra	1993 May 20.3	2.7311	1.8522	12.8	275.5	7.2	ESO/61−cm	AE
122 Gerda	1994 Oct. 16.3	3.3076	2.3109	0.3	22.3	− 0.9	ESO/50−cm	JP
146 Lucina	1992 Sep. 2.1	2.6990	1.8452	13.8	302.8	− 15.2	ESO/61−cm	AE
146 Lucina	1992 Sep. 5.1	2.7010	1.8719	14.6	302.5	− 15.1	ESO/61−cm	AE
146 Lucina	1992 Sep. 6.1	2.7017	1.8811	14.9	302.4	− 15.1	ESO/61−cm	AE
186 Celuta	1994 Sep. 19.2	2.0100	1.0986	16.4	324.3	−14.2	ESO/50−cm	JP
186 Celuta	1994 Sep. 20.2	2.0102	1.1043	16.7	324.2	−14.0	ESO/50−cm	JP
233 Asterope	1995 Mar. 05.1	2.9196	1.9661	6.5	147.6	− 10.7	ESO/61−cm	AE
233 Asterope	1995 Mar. 07.1	2.9201	1.9745	7.2	147.2	− 10.6	ESO/61−cm	AE
233 Asterope	1995 Mar. 09.1	2.9207	1.9840	7.8	146.8	− 10.6	ESO/61−cm	AE
233 Asterope	1995 Mar. 11.1	2.9212	1.9946	8.5	146.4	− 10.5	ESO/61−cm	AE
233 Asterope	1995 Mar. 26.1	2.9245	2.1044	13.1	144.2	− 9.7	ESO/61−cm	AE

Table 2. continued

Asteroid	Date (UT)	r AU	Δ AU	α deg	λ 2000.0	β 2000.0	Tel/Inst	Observer
238 Hypatia	1994 Oct. 20.3	2.6835	2.0721	19.2	88.1	− 14.6	ESO/50−cm	JP
238 Hypatia	1994 Oct. 21.3	2.6841	2.0617	19.0	88.1	− 14.7	ESO/50−cm	JP
238 Hypatia	1994 Oct. 23.3	2.6852	2.0412	18.6	88.2	− 14.9	ESO/50−cm	JP
291 Alice	1996 Feb. 18.3	2.1134	1.6021	26.6	222.0	1.4	ESO/61−cm	AE+AN
291 Alice	1996 Feb. 22.3	2.1172	1.5607	26.0	222.8	1.4	ESO/61−cm	AE+AN
291 Alice	1996 Feb. 23.3	2.1182	1.5505	25.8	222.9	1.5	ESO/61−cm	AE+AN
306 Unitas	1996 Feb. 8.3	2.6653	1.7414	9.2	164.3	2.5	ESO/61−cm	AE+AN
306 Unitas	1996 Feb. 20.2	2.6561	1.6792	4.1	161.6	3.1	ESO/61−cm	AE+AN
306 Unitas	1996 Feb. 24.2	2.6528	1.6673	2.5	160.6	3.3	ESO/61−cm	AE+AN
306 Unitas	1996 Feb. 28.2	2.6494	1.6601	1.3	159.6	3.5	ESO/61−cm	AE+AN
323 Brucia	1993 May 15.2	2.8188	1.9007	10.5	260.0	17.1	ESO/61−cm	AE
323 Brucia	1993 May 16.2	2.8161	1.8907	10.1	259.8	17.0	ESO/61−cm	AE
323 Brucia	1993 May 17.2	2.8138	1.8826	9.8	259.5	17.0	ESO/61−cm	AE
346 Hermentaria	1993 May 15.0	2.1134	1.6021	26.6	222.0	1.4	ESO/61−cm	AE
372 Palma	1994 Aug. 03.3	2.9988	2.2740	15.6	2.7	11.2	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 04.3	2.9961	2.2611	15.4	2.7	11.3	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 06.2	2.9911	2.2371	15.1	2.6	11.6	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 12.3	2.9752	2.1652	13.8	2.3	12.5	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 13.2	2.9726	2.1539	13.6	2.2	12.7	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 15.2	2.9673	2.1320	13.1	2.0	13.0	ESO/61−cm	AE+MG
372 Palma	1994 Aug. 27.3	2.9353	2.0176	10.0	0.4	14.9	ESO/61−cm	AE+MG
372 Palma	1994 Sep. 02.3	2.9194	1.9738	8.4	359.3	15.8	ESO/61−cm	AE+MG
409 Aspasia	1996 Feb. 11.1	2.5620	1.6110	7.4	149.8	− 18.0	ESO/61−cm	AE+AN
435 Ella	1994 Oct. 14.3	2.1029	1.1077	2.5	26.1	0.0	ESO/50−cm	JP
435 Ella	1994 Oct. 14.3	2.1062	1.1099	0.2	25.1	0.1	ESO/50−cm	JP
435 Ella	1994 Oct. 14.3	2.1095	1.1160	2.2	24.2	0.2	ESO/50−cm	JP
435 Ella	1994 Oct. 14.3	2.1104	1.1182	2.7	23.9	0.2	ESO/50−cm	JP
512 Taurinensis	1994 Oct. 19.3	1.6474	0.7426	21.7	352.9	-19.7	ESO/50−cm	JP
512 Taurinensis	1994 Oct. 20.3	1.6483	0.7479	22.1	352.9	-19.5	ESO/50−cm	JP
512 Taurinensis	1994 Oct. 22.3	1.6501	0.7588	22.8	353.0	-19.3	ESO/50−cm	JP
512 Taurinensis	1994 Oct. 23.3	1.6510	0.7645	23.2	353.0	-19.2	ESO/50−cm	JP
550 Senta	1995 Aug. 9.2	2.0321	1.0623	11.8	334.7	15.9	KVI/1−m	TO
550 Senta	1995 Aug. 12.2	2.0335	1.0581	10.8	334.1	16.3	KVI/1−m	TO
550 Senta	1995 Aug. 13.2	2.0340	1.0565	10.4	333.9	16.4	KVI/1−m	TO
595 Polyxena	1994 Oct. 15.5	3.1946	2.1985	1.0	19.5	-2.1	ESO/50−cm	JP
674 Rachele	1992 Sep. 2.1	3.3541	2.5317	11.5	301.6	− 17.4	ESO/61−cm	AE
674 Rachele	1992 Sep. 3.1	3.3530	2.5394	11.7	301.5	− 17.3	ESO/61−cm	AE
674 Rachele	1992 Sep. 5.1	3.3507	2.5555	12.2	301.3	− 17.2	ESO/61−cm	AE
674 Rachele	1992 Sep. 6.1	3.3496	2.5639	12.4	301.2	− 17.2	ESO/61−cm	AE

small tables appearing within each figure. Below we discuss each object in more detail. The periods and colour indices of each asteroid are given in Table 3. We adopted the albedos and taxonomic types from Tedesco (1989) & Tholen (1989) and give these in the last two columns of Table 3. The present data are a valuable addition to the Asteroid Photometric Catalogue (Lagerkvist et al. 1996).

8 Flora

In this study, the S–type asteroid (S0–type in Barucci classification) was observed in 1983, at Siding Springs, and in 1993, at La Silla. This asteroid has been observed previously also at several apparitions by Ahmad (1954), van Houten-Groeneveld & van Houten (1958), Veverka (1971), Vesely & Taylor (1985), Zappalá et al. (1983), Harris & Young (1989), Zhou et al. (1982), Hollis et al. (1987), Di Martino et al. (1989) and Debehogne et al. (1990). The asteroid 8 Flora is nearly spherical with low lightcurve amplitude and with a period of 12.86 hours (Harris & Young 1989) or 12.79 hours (Hollis et al. 1987), which is close to the value given by Di Martino et al. (1989) of 12.87 hours. Our data is in favour of the latter period (Fig. 1). The $B-V$ value 0.91 is slightly redder than 0.88 as given by Tedesco (1989).

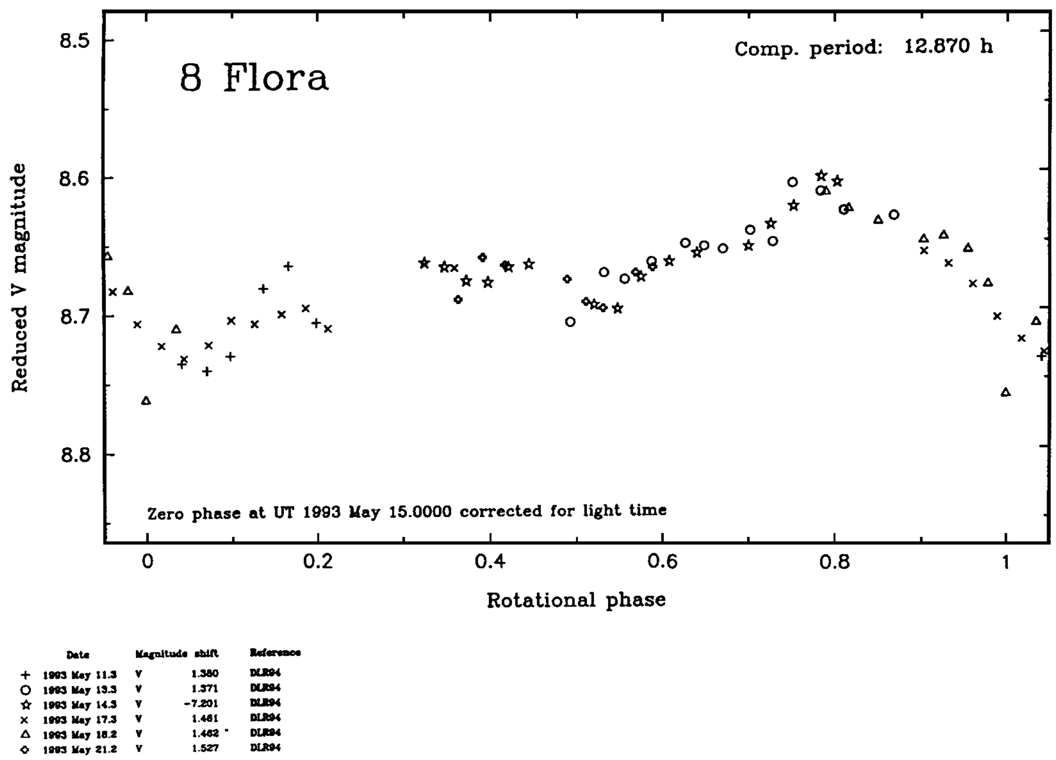

8 Flora
Comp. period: 12.870 h
8.5
8.6
8.7
8.8
Reduced V magnitude
Zero phase at UT 1993 May 15.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1993 May 11.3 V 1.380 DLR94
1993 May 13.3 V 1.371 DLR94
1993 May 14.3 V −7.201 DLR94
1993 May 17.3 V 1.461 DLR94
1993 May 18.2 V 1.462 DLR94
1993 May 21.2 V 1.527 DLR94

Fig. 1.

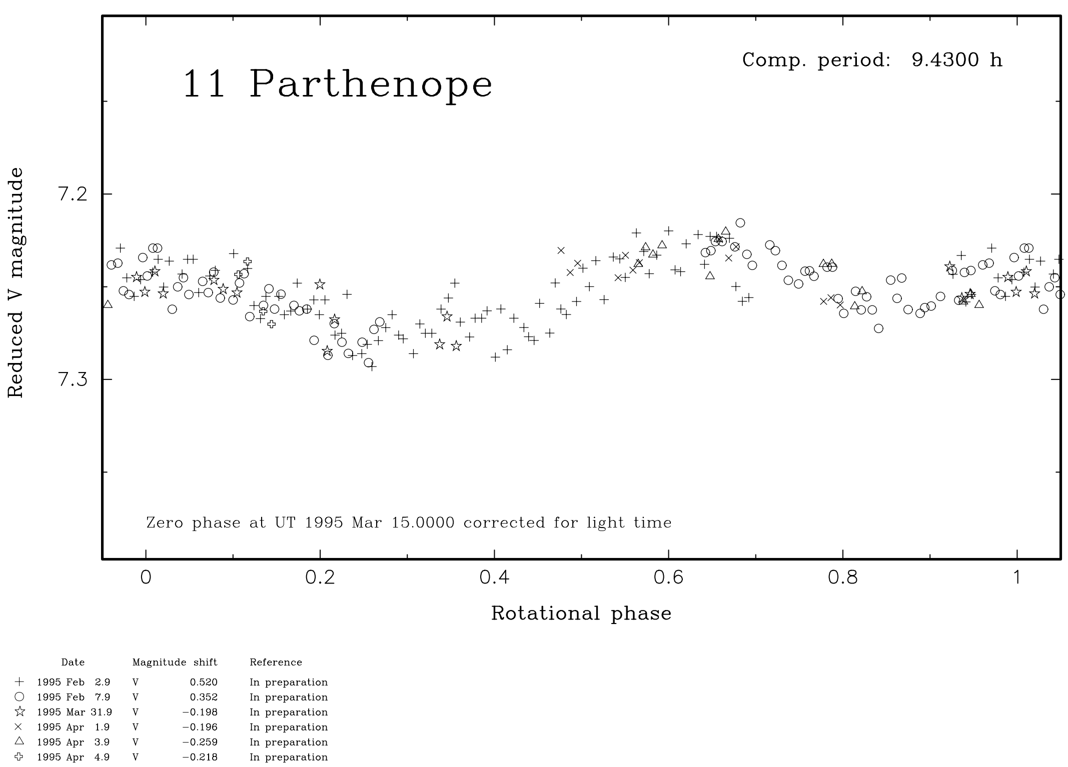

11 Parthenope
Comp. period: 9.4300 h
7.2
7.3
Reduced V magnitude
Zero phase at UT 1995 Mar 15.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1995 Feb 2.9 V 0.520 In preparation
1995 Feb 7.9 V 0.352 In preparation
1995 Mar 31.9 V −0.198 In preparation
1995 Apr 1.9 V −0.196 In preparation
1995 Apr 3.9 V −0.259 In preparation
1995 Apr 4.9 V −0.218 In preparation

Fig. 2.

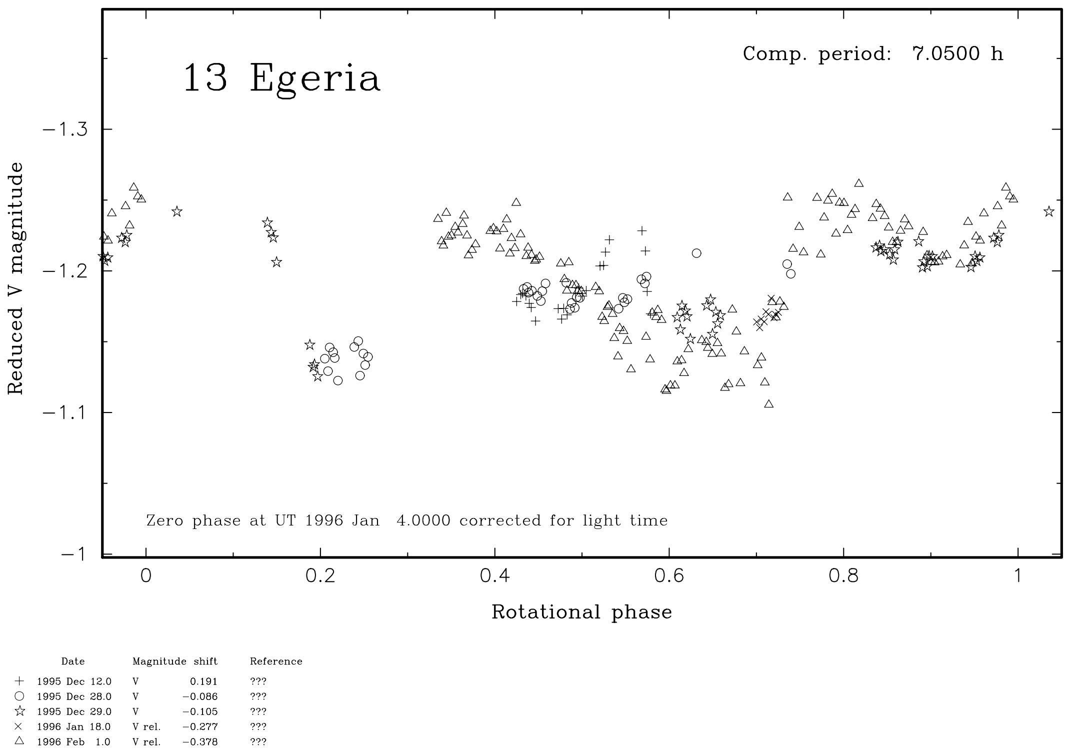

13 Egeria
Comp. period: 7.0500 h
Reduced V magnitude
−1.3
−1.2
−1.1
−1
0
0.2
0.4
0.6
0.8
1
Rotational phase
Zero phase at UT 1996 Jan 4.0000 corrected for light time
Date
Magnitude shift
Reference
1995 Dec 12.0 V 0.191 ???
1995 Dec 28.0 V −0.086 ???
1995 Dec 29.0 V −0.105 ???
1996 Jan 18.0 V rel. −0.277 ???
1996 Feb 1.0 V rel. −0.378 ???

Fig. 3.

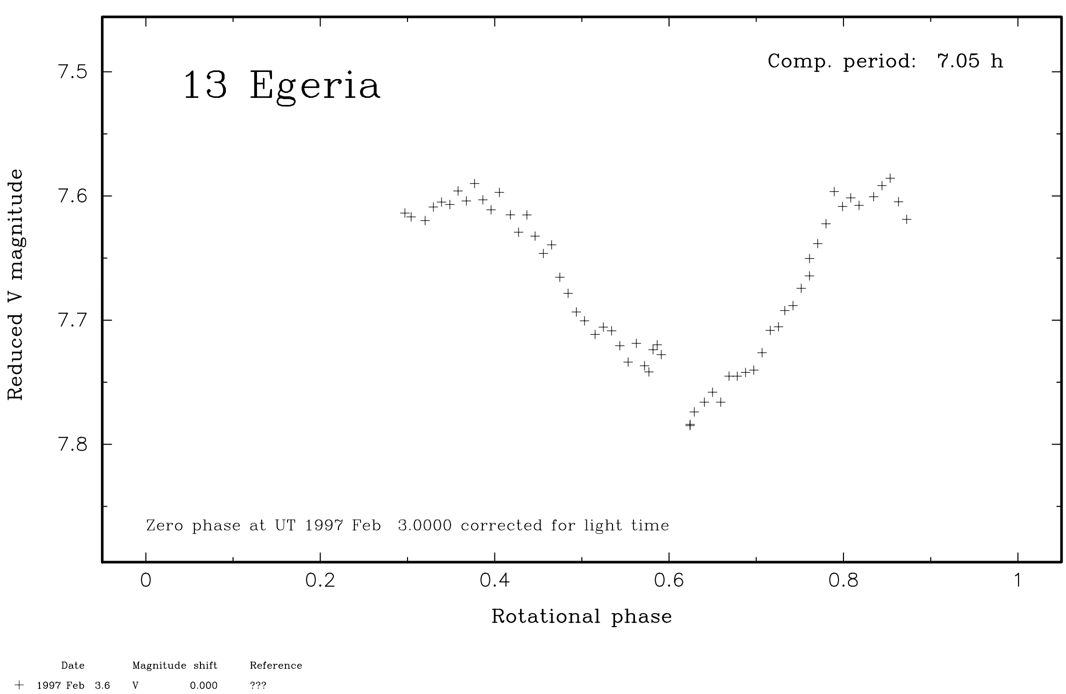

13 Egeria
Comp. period: 7.05 h
Reduced V magnitude
7.5
7.6
7.7
7.8
0
0.2
0.4
0.6
0.8
1
Rotational phase
Zero phase at UT 1997 Feb 3.0000 corrected for light time
Date
Magnitude shift
Reference
1997 Feb 3.6 V 0.000 ???

Fig. 4.

Table 3. Results for the observed asteroids. Rotational period is given to the last significant number

Asteroid		Period (hr)	$(B-V)$ (mag)	Error	$(U-B)$ (mag)	Error	$(V-R)$ (mag)	Error	$(V-I)$ (mag)	Error
8	Flora	12.87	0.91	± 0.01	–	± –	–	± –	–	± –
11	Parthenope	9.43	0.81	± 0.01	–	± –	–	± –	–	± –
13	Egeria	7.05	–	± –	–	± –	–	± –	–	± –
14	Irene	–	0.82	± 0.02	0.37	± 0.02	0.46	± 0.02	0.85	± 0.02
18	Melpomene	–	0.83	± 0.01	0.36	± 0.01	0.45	± 0.01	0.85	± 0.01
24	Themis	–	0.71	± 0.02	0.31	± 0.03	0.33	± 0.02	0.67	± 0.01
25	Phocaea	–	0.94	± 0.07	0.44	± 0.04	0.48	± 0.02	0.93	± 0.01
28	Bellona	–	0.84	± 0.01	0.31	± 0.03	0.45	± 0.02	0.88	± 0.01
31	Euphrosyne	–	0.70	± 0.01	0.29	± 0.02	0.37	± 0.01	0.71	± 0.01
42	Isis	–	0.86	± 0.01	0.46	± 0.02	0.48	± 0.02	0.89	± 0.01
47	Aglaja	–	0.69	± 0.01	0.28	± 0.03	0.36	± 0.01	0.68	± 0.01
48	Doris	–	0.73	± 0.04	0.42	± 0.05	0.35	± 0.03	0.66	± 0.03
56	Melete	–	0.73	± 0.03	0.33	± 0.02	0.42	± 0.01	0.80	± 0.02
64	Angelina	–	0.72	± 0.04	0.26	± 0.03	0.46	± 0.02	0.85	± 0.02
71	Niobe	14.38	–	± –	–	± –	–	± –	–	± –
110	Lydia	–	0.71	± 0.02	–	± –	–	± –	–	± –
114	Kassandra	–	0.76	± 0.02	–	± –	–	± –	–	± –
121	Hermione	–	0.73	± 0.02	0.33	± 0.03	0.39	± 0.03	0.75	± 0.03
122	Gerda	–	0.84	± 0.03	0.45	± 0.03	0.47	± 0.03	0.94	± 0.03
146	Lucina	–	0.70	± 0.02	–	± –	–	± –	–	± –
186	Celuta	–	0.85	± 0.02	0.51	± 0.06	0.47	± 0.03	0.89	± 0.03
233	Asterope	19.743	–	± –	–	± –	–	± –	–	± –
238	Hypatia	8.86	0.78	± 0.03	–	± –	–	± –	–	± –
287	Nephthys	–	0.86	± 0.02	0.38	± 0.03	0.50	± 0.03	0.91	± 0.03
291	Alicia	4.32	–	± –	–	± –	–	± –	–	± –
306	Unitas	8.74	–	± –	–	± –	–	± –	–	± –
313	Chaldea	–	0.72	± 0.01	0.31	± 0.03	0.35	± 0.02	0.69	± 0.01
323	Brucia	–	0.88	± 0.02	–	± –	–	± –	–	± –
346	Hermentaria	–	0.93	± 0.03	–	± –	–	± –	–	± –
359	Georgia	–	0.74	± 0.03	0.30	± 0.05	0.40	± 0.02	0.83	± 0.05
372	Palma	8.58	–	± –	–	± –	–	± –	–	± –
409	Aspasia	9.02	–	± –	–	± –	–	± –	–	± –
435	Ella	4.624	0.72	± 0.01	0.27	± 0.01	0.38	± 0.03	0.77	± 0.01
451	Patientia	–	0.68	± 0.03	0.30	± 0.03	0.36	± 0.01	0.66	± 0.03
487	Venetia	–	0.87	± 0.03	0.58	± 0.12	0.46	± 0.02	0.88	± 0.02
505	Cava	–	0.67	± 0.02	–	± –	–	± –	–	± –
512	Taurinensis	5.59	0.93	± 0.03	0.64	± 0.09	0.49	± 0.01	0.92	± 0.02
595	Polyxena	8–9	0.71	± 0.02	–	± –	–	± –	–	± –
674	Rachele	28.2	0.84	± 0.03	–	± –	–	± –	–	± –
704	Interamnia	–	0.67	± 0.02	0.23	± 0.01	0.34	± 0.04	0.68	± 0.01

11 Parthenope

11 Parthenope was observed with the Swedish 60 cm-telescope on La Palma, Canary Islands. 11 Parthenope has been observed previously by van Houten–Groeneveld & van Houten (1958); Wood & Kuiper (1963); Zappalá et al. (1983); Barucci et al. (1985); Harris et al. (1992); Mellillo (1996), and Lang (1996). The period estimation of Barucci et al. (1985), is 7.83 hr but does not agree with the present data. We find that 9.43 hr fits better to present and past observations (Fig. 2). Thus we will adopt the new period for 11 Parthenope. Extensive BV-observations were made on two nights and there was excellent agreement of lightcurves in both colours. Thus there are no major albedo features which cause colour differences at this aspect angle of the asteroid.

13 Egeria

13 Egeria was observed with the Swedish 60 cm-telescope on La Palma, Canary Islands (Fig. 3) and the 70–cm telescope of Kharkov Observatory (Fig. 4). The G–type asteroid 13 Egeria has been observed previously by Chang & Chang (1963) and Licandro et al. (1990). The period derived from these observations by Lagerkvist & Claesson

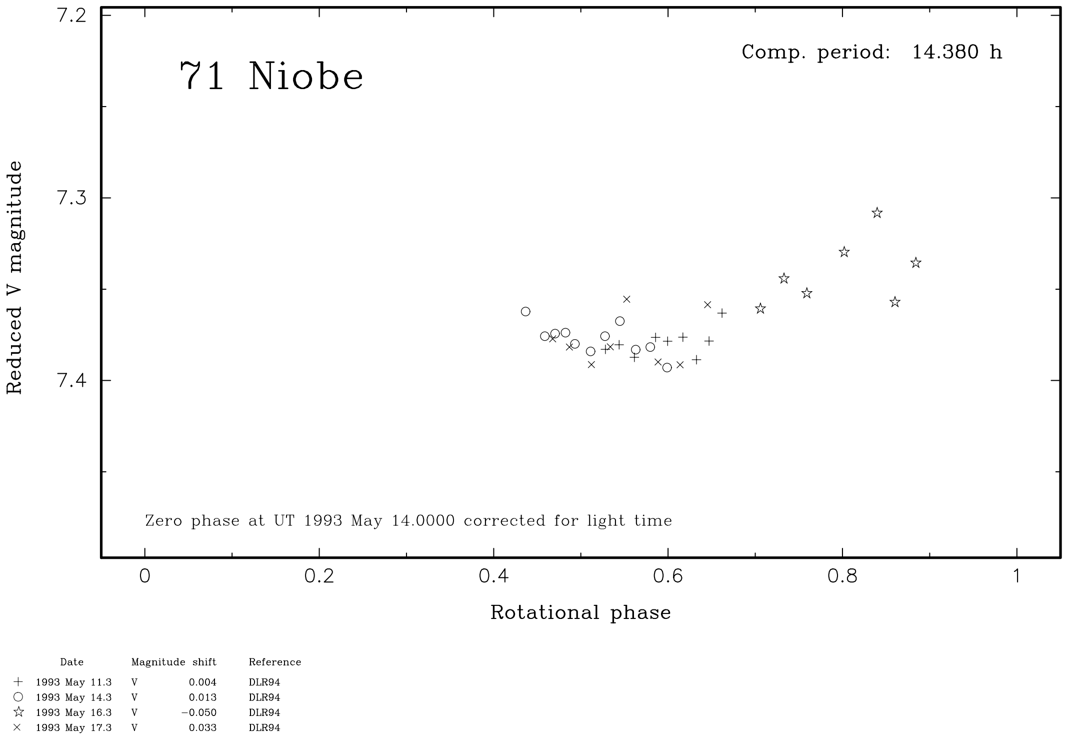


Fig. 5.

(1996) was 7.0 hours. We find a period of 7.05 hours (Fig. 3).

71 Niobe

71 Niobe has been observed previously by Lustig & Dvorak (1975); Barucci et al. (1985); Harris & Young (1989). The lightcurve of this S-type (S0 in the Barucci classification) is very complicated with three maxima. Unfortunately, our observations include a number of gaps that prevent us from improving the rotational period of the asteroid. According to Lustig & Dvorak (1975) the rotational period is 11.213 hours, and according to Harris & Young (1989) 14.38 hours. This is also consistent with observations by Barucci et al. (1985). The period of 14.38 hours seems to fit our observations best (Figs. 5 and 6).

110 Lydia

110 Lydia has previously been observed quite extensively by Taylor et al. (1971); Dotto et al. (1992) and Lagerkvist et al. (1995). This object is an M–type asteroid (M0 in the Barucci classification). Our observations consist of only a few points for this asteroid.

114 Kassandra

114 Kassandra is a rare T–type asteroid (D3 in the Barucci classification) and has been observed by Gil Hutton & Blain (1988); Harris & Young (1983); Harris & Young (1989) and Harris et al. (1992). According to Harris et al. (1992) the period of the asteroid was determined to be 10.758 hours. Our sparse set of observations agrees with this period (Fig. 7).

146 Lucina

This asteroid has previously been observed during one apparition only by Schober (1983b) and Harris & Young (1989). Asteroid 146 Lucina is a C–type asteroid (C0 in the Barucci classification). Harris & Young (1979) determined the rotational period to be 18.557 hours, which is confirmed by our rather sparse set of observations (Fig. 8). This period was close to the value given by Schober (1983b).

186 Celuta

186 Celuta is an S–type asteroid which has been observed by Lagerkvist (1978a) and Lagerkvist & Petterson (1978). From those observations the period was estimated to be 15 hours by Lagerkvist & Claesson (1996). Our observations of this asteroid consist of only a few points during two nights, and agree with the previous period. The $UBVRI$-colours for 186 Celuta are to be found in Table 3, and they are in reasonable agreement with those of Tedesco (1989).

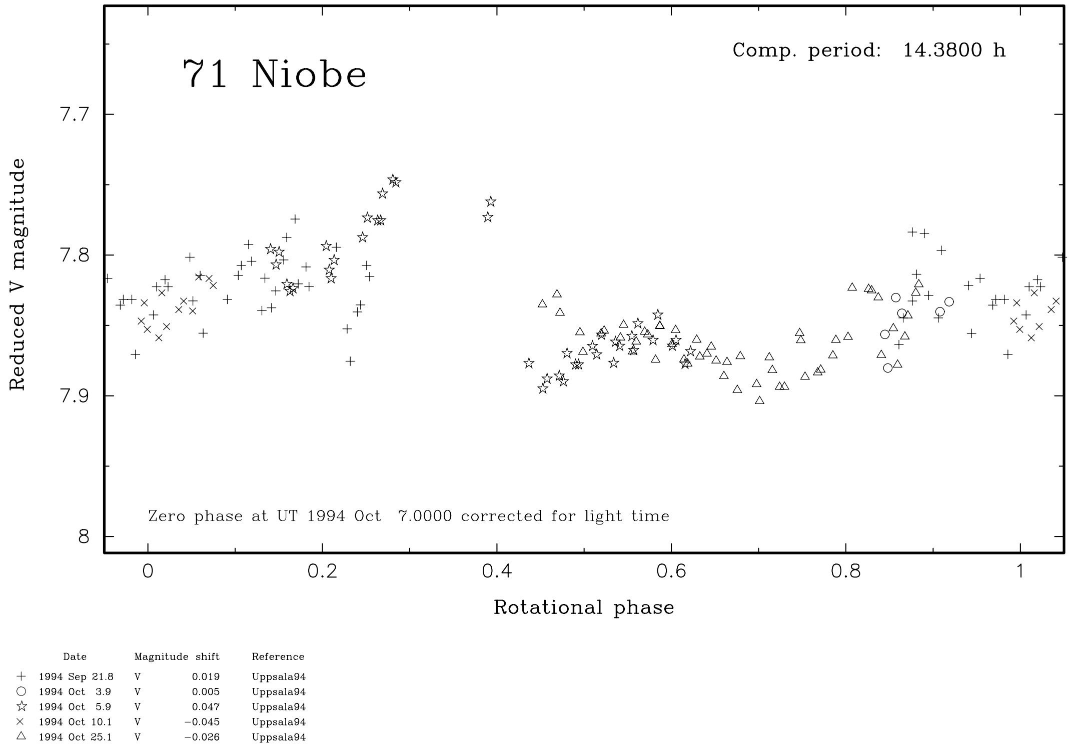

71 Niobe
Comp. period: 14.3800 h
Reduced V magnitude
7.7
7.8
7.9
8
Zero phase at UT 1994 Oct 7.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1994 Sep 21.8 V 0.019 Uppsala94
1994 Oct 3.9 V 0.005 Uppsala94
1994 Oct 5.9 V 0.047 Uppsala94
1994 Oct 10.1 V −0.045 Uppsala94
1994 Oct 25.1 V −0.026 Uppsala94

Fig. 6.

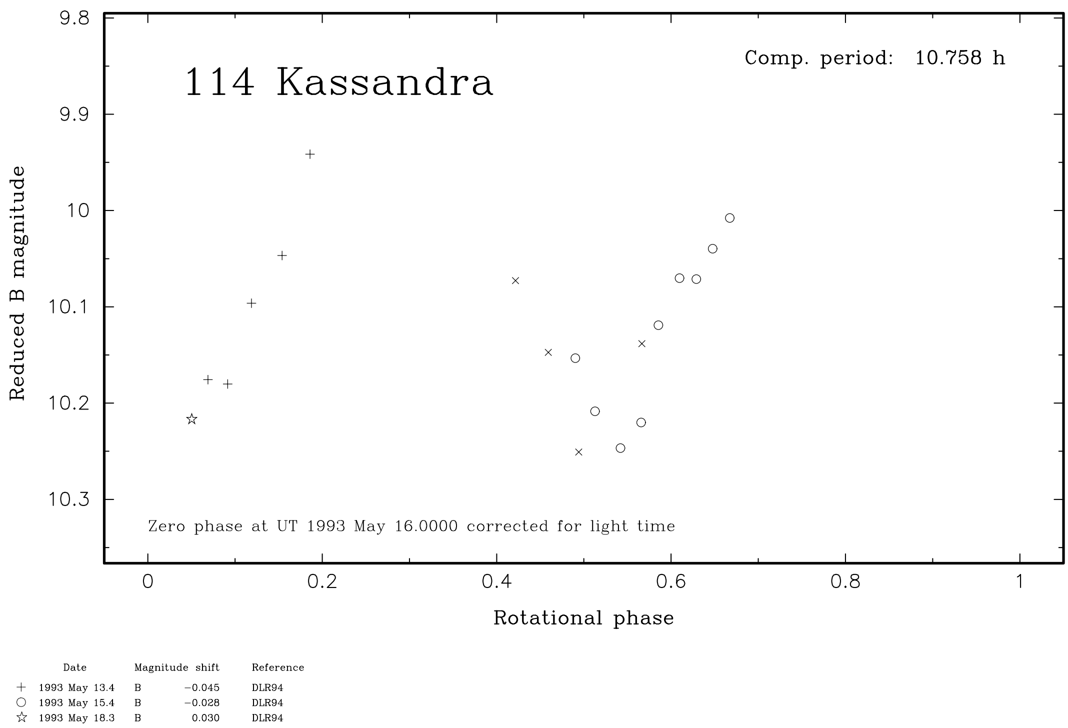

114 Kassandra
Comp. period: 10.758 h
Reduced B magnitude
9.8
9.9
10
10.1
10.2
10.3
Zero phase at UT 1993 May 16.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1993 May 13.4 B −0.045 DLR94
1993 May 15.4 B −0.028 DLR94
1993 May 18.3 B 0.030 DLR94
1993 May 20.3 B 0.044 DLR94

Fig. 7.

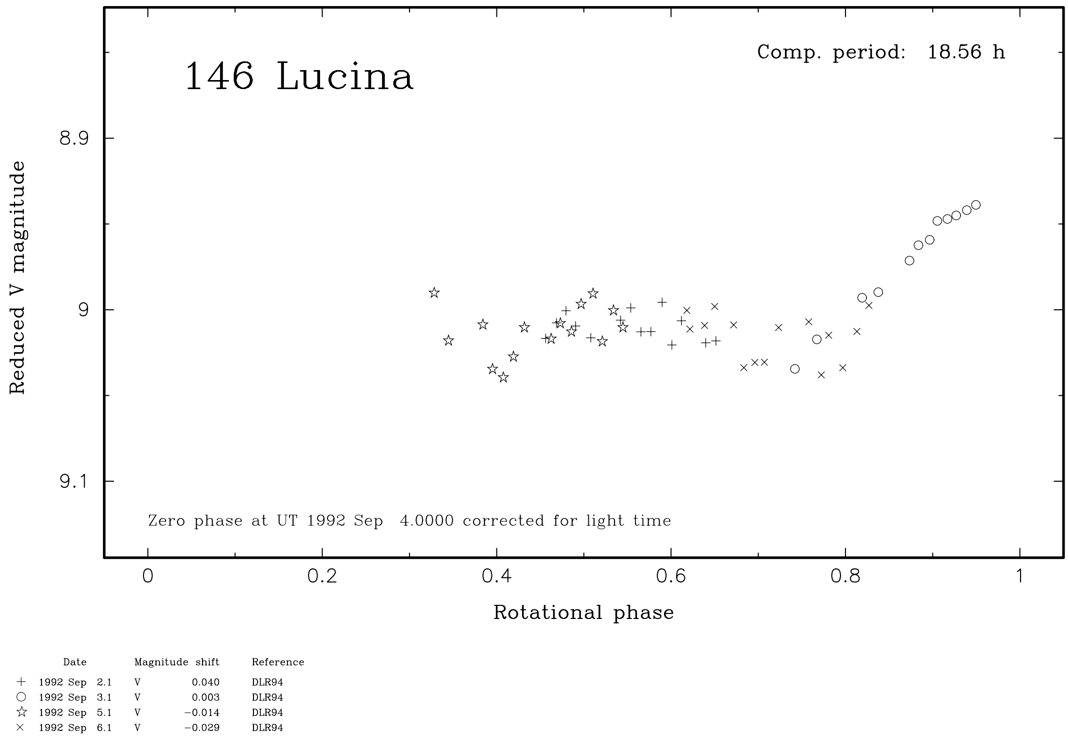


Fig. 8.

233 Asterope

This asteroid is a T–type asteroid (D3 in the Barucci classification) and has previously been observed by Harris & Young (1983) and Lagerkvist et al. (1995b). We find a period of 19.743 hours (Fig. 9), which is consistent with previous estimates.

238 Hypatia

The C-type (C0) asteroid 238 Hypatia has previously been observed during the apparitions of 1981, 1988 and 1991 by Schober (1983b); Lagerkvist et al. (1992); Shevchenko et al. (1992) and Lagerkvist et al. (1995). Colour indices are consistent with the values given by Tedesco (1979). Our data do not allow anything definite to be said about the rotation period. The value of 8.86 hr (Lagerkvist et al. 1995), gives a good fit to our sparse observations (Fig. 10). The $B-V$ value of 0.78 is redder than the value of 0.72 given by Tedesco (1989).

291 Alice

This asteroid was observed by Lagerkvist (1976) and Binzel & Mulholland (1983). From their observations the rotation period is found to be 4.32 hours. Our observations agree fully with this period (Fig. 11). This object is suitable for a determination of the spin vector if data can be obtained during one more apparition.

306 Unitas

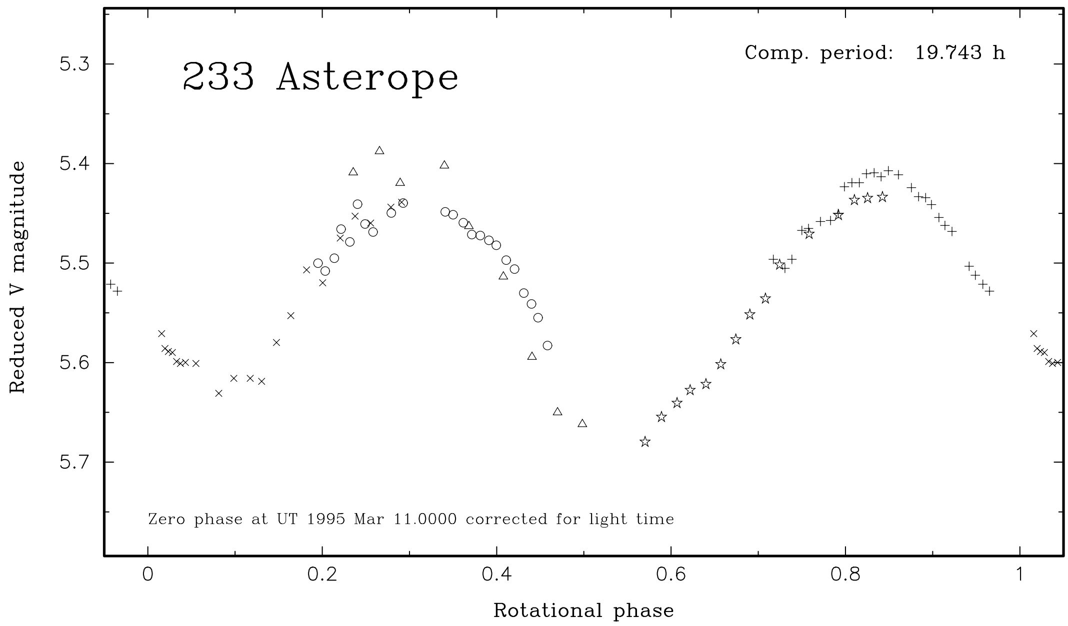
The S–type asteroid 306 Unitas was observed previously by Harris & Young (1983) and Hainaut–Rouelle et al. (1995). From our observations the rotation period of this asteroid is found to be 8.74 hours (Fig. 12), which is an improvement over the previous observations. This asteroid is also suitable for a future determination of the spin vector.

323 Brucia

323 Brucia is an S–type asteroid which has been observed by Tedesco (1979) and Schober et al. (1993). A rotational period of 9.46 hours is derived from these observations (Lagerkvist & Claesson 1996). Our observations consist of only a few points during three nights, which fit reasonably well with this period. Our $B-V$ value of 0.88 is close to the value given by Tedesco (1989).

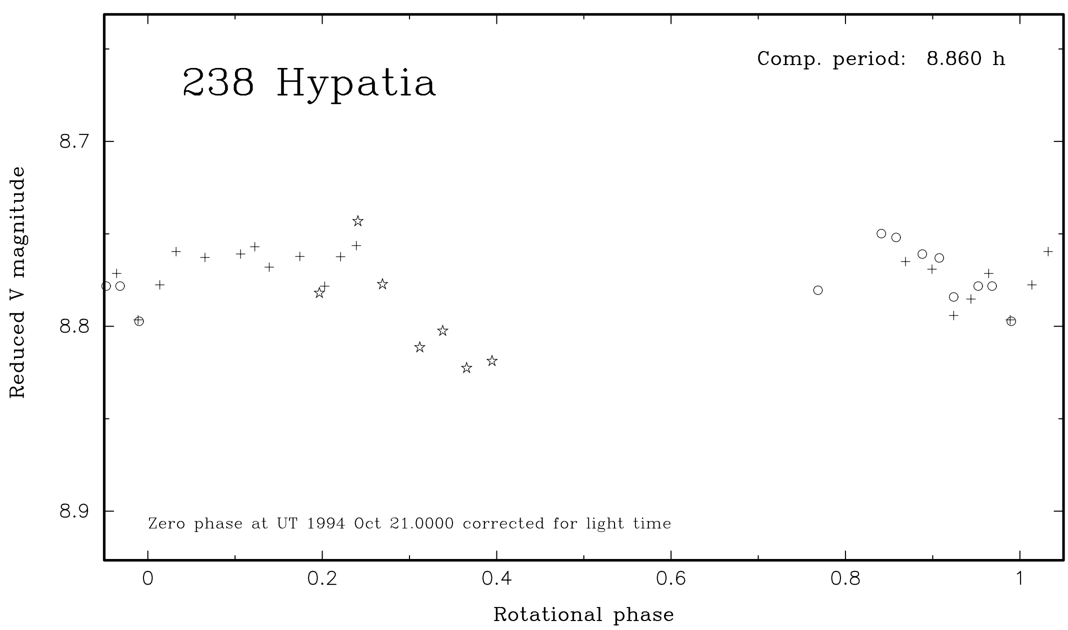
346 Hermentaria

Only a few points during one night were observed for this asteroid. This asteroid has been observed by Harris & Young (1989) and Harris et al. (1992). The $B-V$ value of 0.93 observed by us is redder than the value of 0.83 given by Tedesco (1989).



	Date	Magnitude	shift	Reference
+	1995 Mar 5.1	V	−3.213	DLR95
○	1995 Mar 7.1	V	9.844	DLR95
☆	1995 Mar 9.1	V	−3.277	DLR95
×	1995 Mar 11.1	V	−3.354	DLR95
△	1995 Mar 26.1	V rel.	7.258	DLR95

Fig. 9.



	Date	Magnitude	shift	Reference
+	1994 Oct 20.3	V	−0.016	Uppsala94
○	1994 Oct 21.3	V	0.008	Uppsala94
☆	1994 Oct 23.3	V	0.009	Uppsala94

Fig. 10.

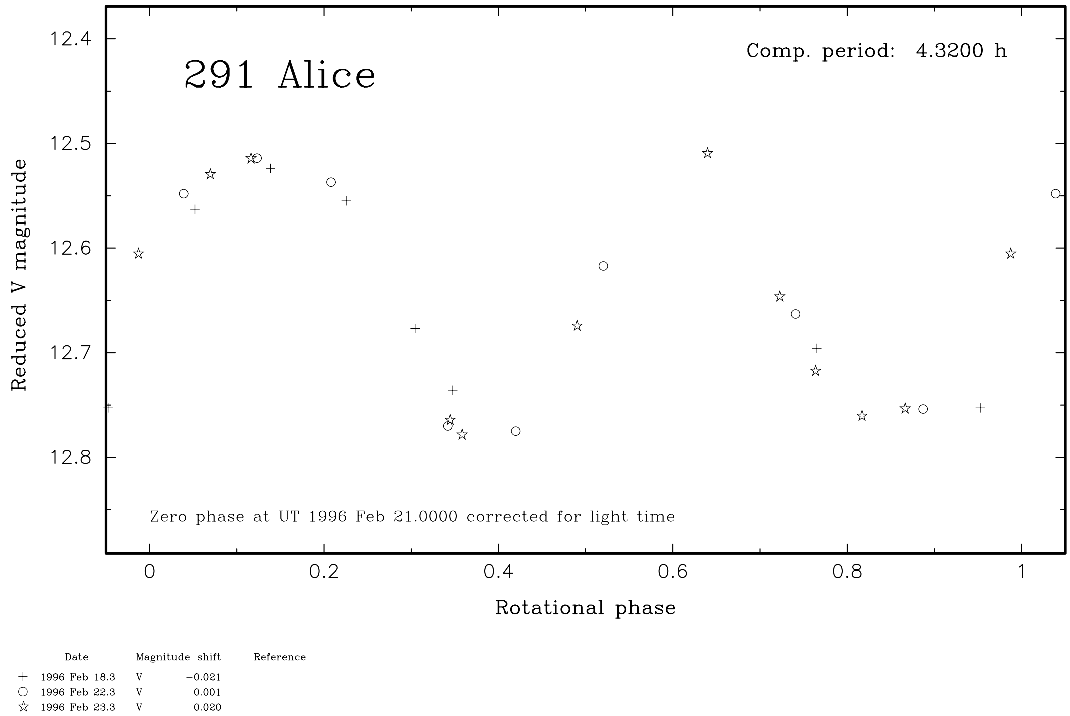

291 Alice
Comp. period: 4.3200 h
Reduced V magnitude
12.4
12.5
12.6
12.7
12.8
Zero phase at UT 1996 Feb 21.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1996 Feb 18.3 V −0.021
1996 Feb 22.3 V 0.001
1996 Feb 23.3 V 0.020

Fig. 11.

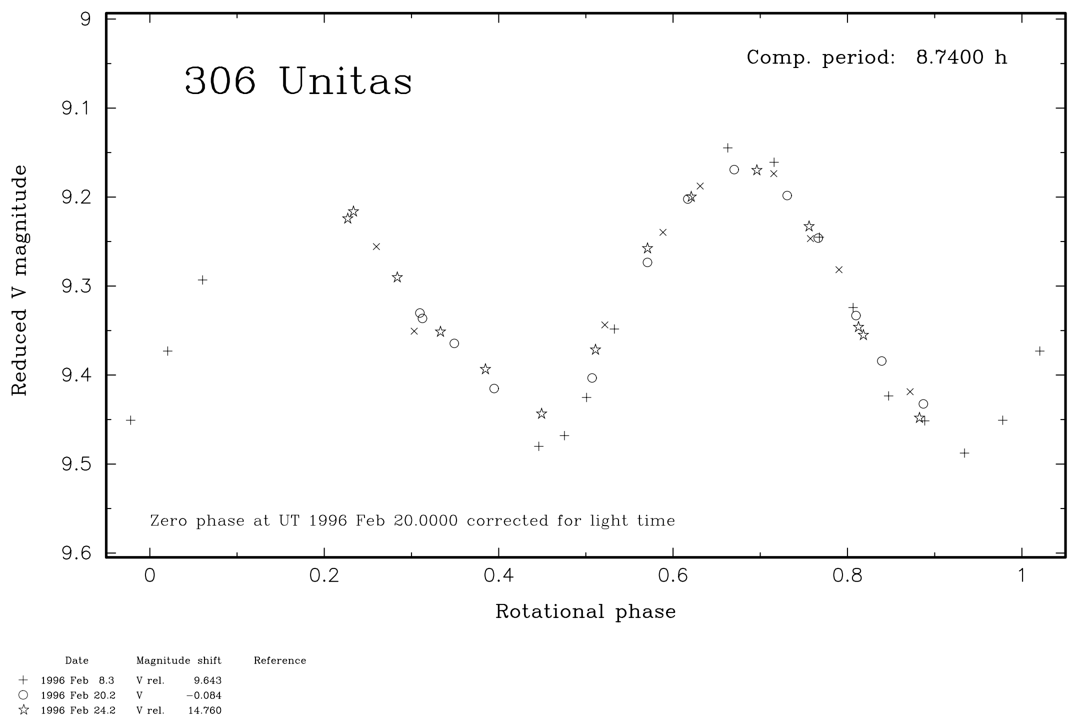
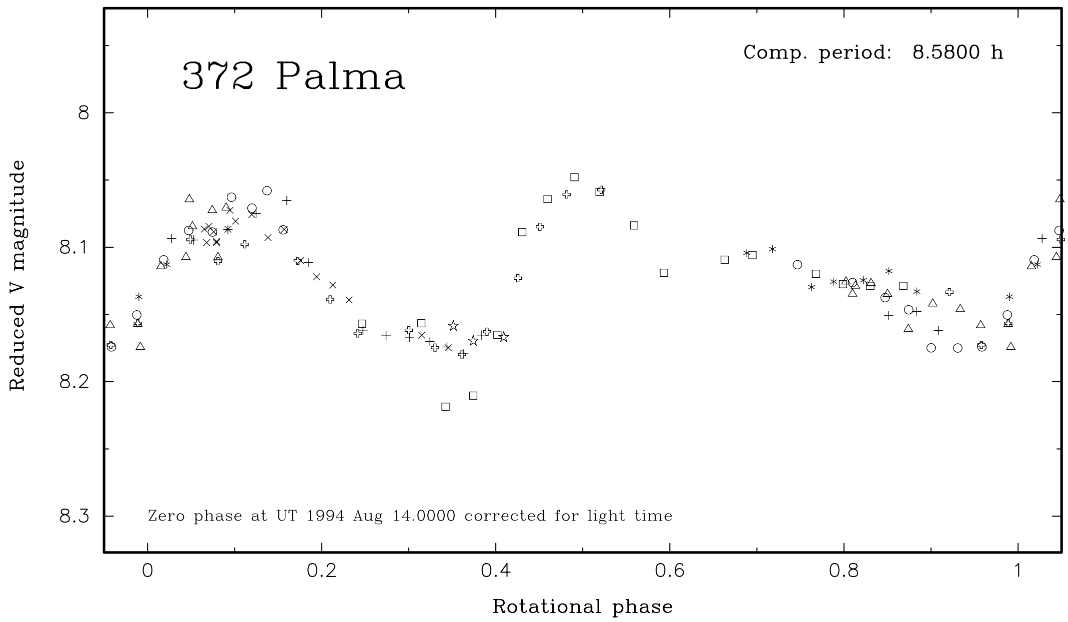
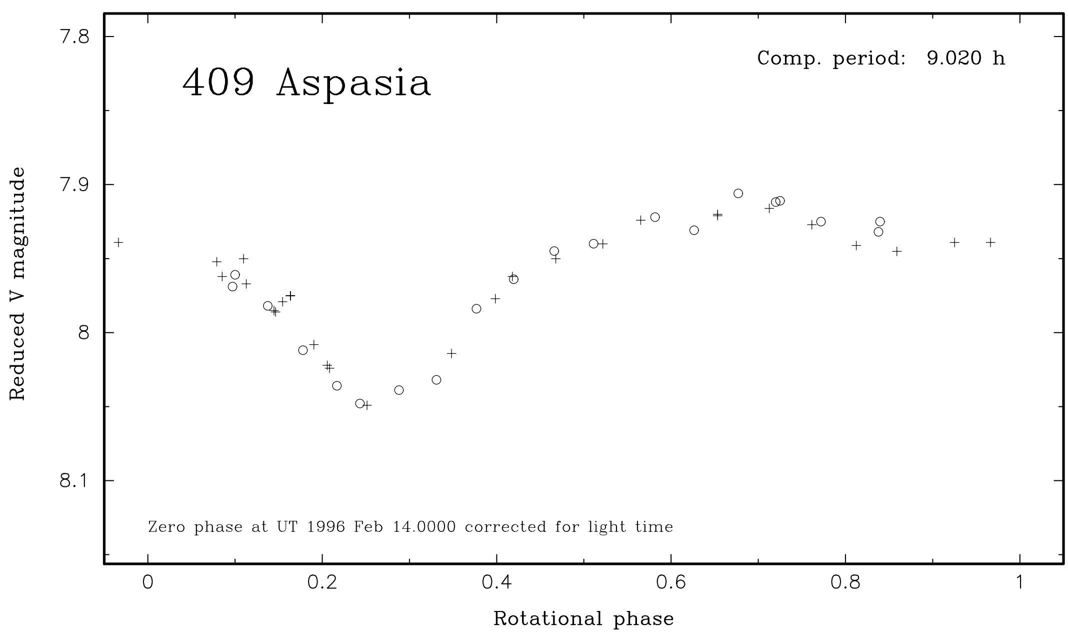

306 Unitas
Comp. period: 8.7400 h
Reduced V magnitude
9
9.1
9.2
9.3
9.4
9.5
9.6
Zero phase at UT 1996 Feb 20.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1996 Feb 8.3 V rel. 9.643
1996 Feb 20.2 V −0.084
1996 Feb 24.2 V rel. 14.760
1996 Feb 28.2 V 0.084

Fig. 12.



	Date	Magnitude	shift	Reference
+	1994 Aug 3.3	V	−0.059	DLR94
○	1994 Aug 4.3	V	−0.048	DLR94
☆	1994 Aug 6.2	V	0.061	DLR94
×	1994 Aug 27.3	V rel.	11.029	DLR94
△	1994 Sep 2.3	V rel.	11.592	DLR94
✙	1994 Aug 12.2	V	0.014	DLR94
∗	1994 Aug 13.2	V	0.001	DLR94
□	1994 Aug 15.2	V	0.030	DLR94

Fig. 13.



	Date	Magnitude	shift	Reference
+	1996 Feb 11.1	V	−0.001	???
○	1996 Feb 17.1	V	0.001	???

Fig. 14.

372 Palma

The BFC–type asteroid 372 Palma has been observed during several apparitions by Zappalá et al. (1983); Haupt & Hanslmeier (1985); Weidenschilling et al. (1990) and Hainaut-Rouelle et al. (1995). A period of 17.4 hours was preferred in these studies. We find a period of 8.58 hours (Fig. 13), which fits the present and previous data better. The lightcurve of 372 Palma has many fine details as also reported by Hainaut–Rouelle et al. (1995).

409 Aspasia

409 Aspasia is an CX–type asteroid and has been observed also at several apparitions by Lagerkvist (1981); Hanslmeier (1982); Di Martino & Cacciatori (1984) and Hainaut–Rouelle et al. (1995). The latter two determined a rotational period of 9.03 hours. Our observations give a slightly shorter rotational period of 9.02 hours (Fig. 14).

435 Ella

The DCX–type asteroid 435 Ella has been observed previously during the 1986 apparition by Barucci et al. (1992). They calculated a value of 4.623 hours for the rotation period. The best fit for the lightcurve for our set of data is given by the period of 4.264 hours (Fig. 15). The $UBVRI$-colours in Table 3 confirm the previous classification of this asteroid. The steep rise of brightness for phase angles under 3 degrees indicates a very steep opposition spike. More observations are needed to confirm this.

512 Taurinensis

512 Taurinensis is an S-type asteroid, with a rotation period of 5.59 hours (Lagerkvist & Claesson 1996). The asteroid has been observed previously during the 1981 apparition by Lagerkvist & Kamél (1982), and Harris et al. (1992). Our observations confirm fully the previous rotation period (Fig. 16). The colour indices also agree with the previous values. The lightcurve has the same type of variability in the secondary maximum as was present in the lightcurve during the 1981 apparition (Lagerkvist & Kamel 1982).

550 Senta

550 Senta has previously been observed during one apparition only by Schevchenko et al. (1992) and Di Martino et al. (1994). Our data are very noisy and do not allow us to say much about this asteroid.

595 Polyxena

We observed 595 Polyxena during one night and no definite period can be determined. The $B-V$ index of 0.71 suggests that 595 Polyxena is a C–type asteroid. This asteroid has been previously observed by Hainaut–Rouelle et al. (1995). They found a rotation period of 5.903 hours, with one maximum for this asteroid. This value does not agree with the present data. We would suggest that the period lies between 8 and 9 hours and that the lightcurve has two maxima (Fig. 17).

674 Rachele

S–type asteroid 674 Rachele has been observed by Harris & Young (1980); Zappalá et al. (1983); Zeigler et al. (1986); Harris & Young (1989) and Harris et al. (1992). Our data seem to support the suggestion by Harris & Young (1979) that the asteroid has a long period of 30.9 hours. We adopt a 28.2 hours period (Fig. 18) if the lightcurve has two maxima and two minima. Our $B-V$ value of 0.84 is slightly bluer than the value of 0.88 given by Tedesco (1979).

Colour observations

In addition to the lightcurves we present here, $UBVRI$-colours for 14 Irene, 25 Phocaea and 64 Angelina were measured. In addition we publish here the $UBVRI$-colours of 18 Melpomene, 24 Themis, 28 Bellona, 31 Euphrosyne, 42 Isis, 47 Aglaja, 48 Doris, 50 Virginia, 56 Melete, 121 Hermione, 122 Gerda, 186 Celuta, 287 Nephthys, 313 Chaldaea, 359 Georgia, 451 Patientia, 487 Venetia, 505 Cava and 704 Interamnia (Table II). The $(B-V)$ and $(U-B)$ indices agree quite well with the previous values (Tedesco 1989) except for $(U-B)$ values. We get larger $(U-B)$ values for 487 Venetia and 512 Taurinensis and smaller for 48 Doris, 238 Hypatia and 287 Nephthys. The $(V-R)$ and $(V-I)$ indices were measured for the first time for these object (see Table 3).

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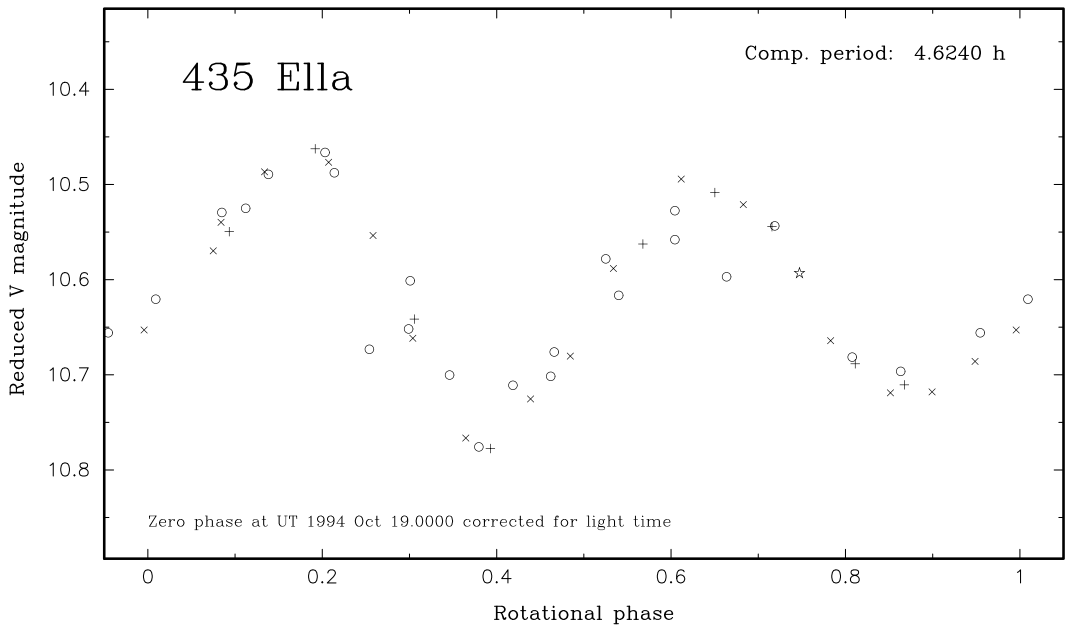
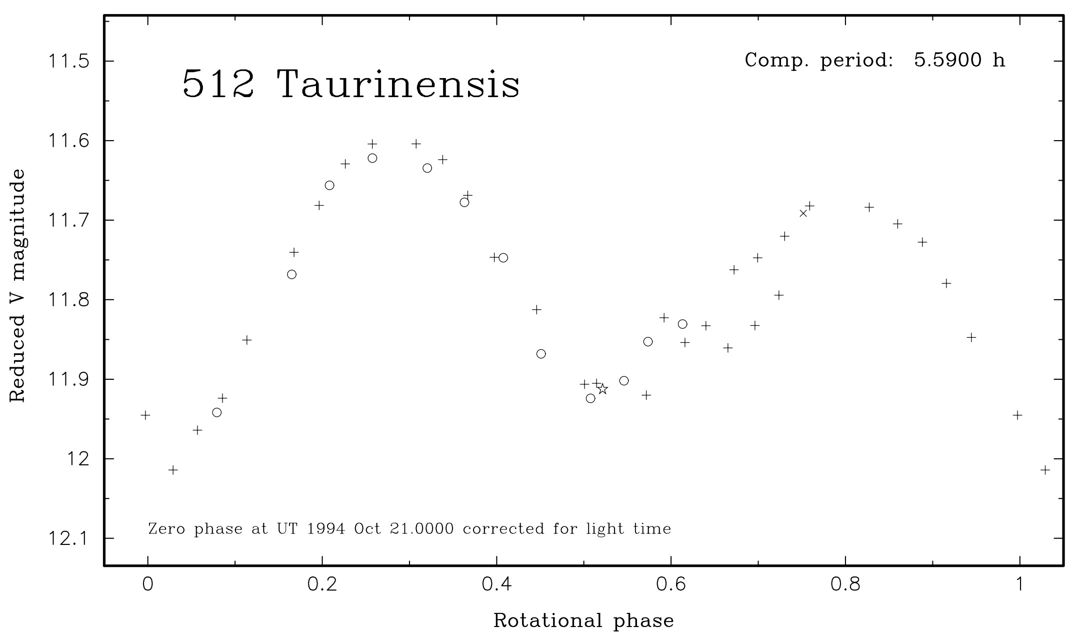


	Date	Magnitude shift		Reference
+	1994 Oct 14.3	V	0.028	In preparation
○	1994 Oct 18.3	V	0.219	In preparation
☆	1994 Oct 22.3	V	−0.268	In preparation
×	1994 Oct 23.3	V	0.021	In preparation

Fig. 15.



	Date	Magnitude shift		Reference
+	1994 Oct 19.3	V	0.035	In preparation
○	1994 Oct 20.3	V	0.033	In preparation
☆	1994 Oct 22.3	V	−0.026	In preparation
×	1994 Oct 23.3	V	−0.043	In preparation

Fig. 16.

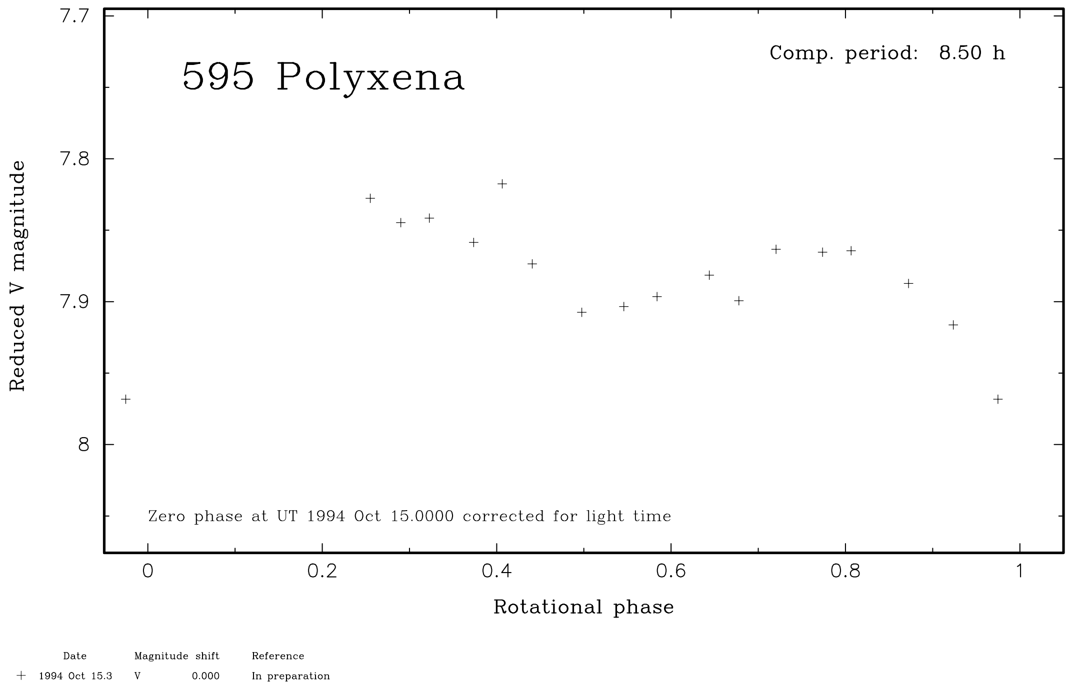

595 Polyxena
Comp. period: 8.50 h
Reduced V magnitude
7.7
7.8
7.9
8
Zero phase at UT 1994 Oct 15.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1994 Oct 15.3 V 0.000 In preparation

Fig. 17.

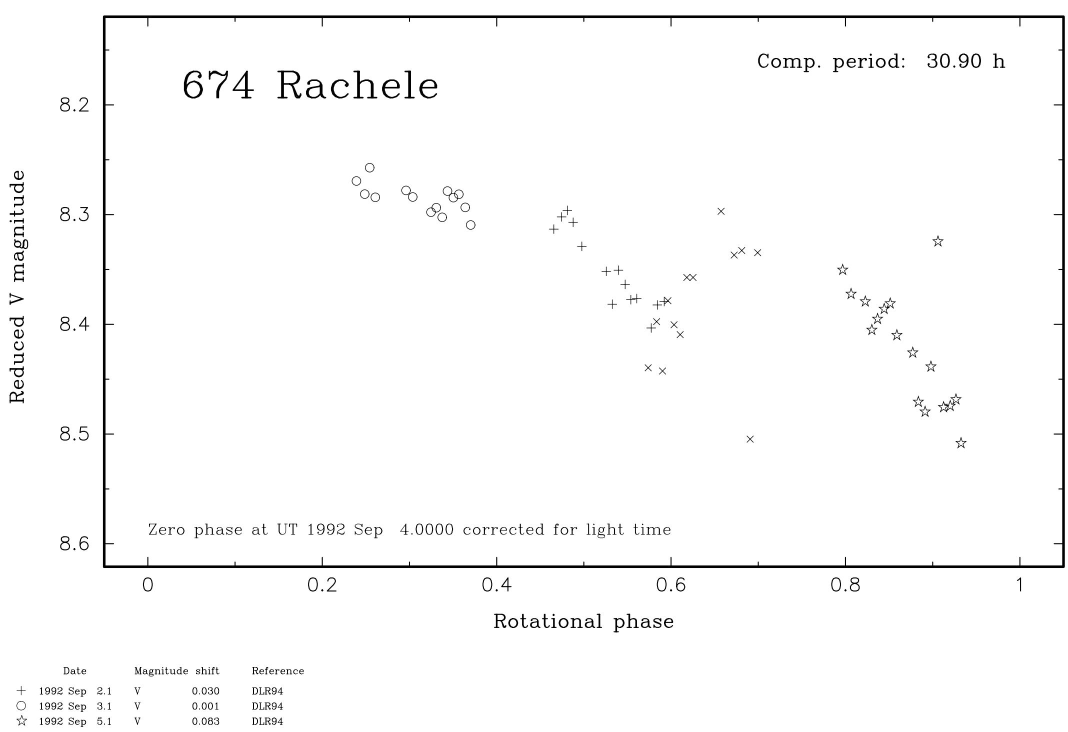

674 Rachele
Comp. period: 30.90 h
Reduced V magnitude
8.2
8.3
8.4
8.5
8.6
Zero phase at UT 1992 Sep 4.0000 corrected for light time
0
0.2
0.4
0.6
0.8
1
Rotational phase
Date Magnitude shift Reference
1992 Sep 2.1 V 0.030 DLR94
1992 Sep 3.1 V 0.001 DLR94
1992 Sep 5.1 V 0.083 DLR94
1992 Sep 6.1 V 0.007 DLR94

Fig. 18.

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