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I. Photometric survey of the Flora region*

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ABSTRACT

Context. Recent studies have uncovered evidence that the statistical properties of asteroids' physical parameters are a fundamental source of information on the physics of their collisions and evolution. The analysis of the spin rates and spin vector distributions helps us to understand the role of various known and new effects. The alignment of spin vectors and the correlation of spin rates are for the first time observed for ten members of the Koronis family. These unexpected non-random orientations of the spin axes and correlations of the spin rates, now known as Slivan states are interpreted in terms of a YORP effect and spin-orbit resonances.
Aims. To study non-gravitational-effects, there appears to be a need for new observational campaigns devoted to determining the physical parameters of the asteroid families.
Methods. We analysed the photometric observations of the asteroids, which are the most efficient method of studying asteroid physical parameters.
Results. We report the results of a ten-year long observational survey of the light variations of objects in the Flora region. We present 544 individual lightcurves of 55 objects obtained at various observing geometries. These lightcurves yield new or refined synodic periods for 32 asteroids and confirm period determinations for 23 objects in our sample. To improve the statistics of the Flora family objects, we add to our dataset 91 objects with reliably determined periods. The distribution of rotation rates for the Flora family is non-Maxwellian at a confidence level of 94% and different from those of the Koronis and the Hungaria families. It seems to be consistent with the long-term influence of the YORP effect, although it is also indicative of a younger age for the Flora family compared to both the Koronis and the Hungaria families.
Conclusions. Our new data is a foundation for the spin vector and shape determinations that will be the objectives of the second paper of the series. We search for spin vector and spin periods correlations in order to determine whether Slivan states exist in the Flora family.

Key words. techniques: photometric – minor planets, asteroids: general

* Photometric data is available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsarc.u-strasbg.fr/viz-bin/qcat?J/A+A/546/A72

1. Introduction

The number of known spin vectors of the main belt and near-Earth asteroids is regularly growing with the inclusion of new objects as well as the updating of data for known cases with the arrival of new observations and improved techniques. All of the asteroid spin-vector determinations published in the literature are available at the Poznan Astronomical Observatory website[1]. Up to now, this dataset includes data for about 250 objects although, only 170 have reasonably reliable determinations. For further discussion, we refer to both Kryszczynska et al. (2007), and references therein, and Paolicchi & Kryszczynska (2012).

Recent studies have provided evidence that the statistical properties of asteroid physical parameters are a fundamental source of information about the physics of their collisions and evolution. There are probably several different mechanisms shaping the distribution of spin-rate and spin-vector orientations of small MBAs and NEAs, leading us to expect that the distributions may be non-Maxwellian or even bi-modal. The analysis of the spin rates and spin vector distributions helps us to understand the role of various known and new effects.

Studies of NEA spin vectors, which are mostly smaller than $D < 10$ km, were reported by La Spina et al. (2004) to have a strong and statistically significant excess of retrograde rotators. This result is consistent with theoretical expectations for the Yarkovsky effect, which is assumed to be responsible for injecting main belt asteroids into resonant regions.

The alignment of asteroid spin vectors and the correlation of spin rates were for the first time observed for ten members of the Koronis family (Slivan 2002; Slivan et al. 2003). These unexpected nonrandom orientations of spin axes and corelation of spin rates, now known as Slivan states, were explained by Vokrouhlicky et al. (2003) in terms of the YORP effect and spin-orbit resonaces. They suggested that over the past few Gyr the YORP effect might have been more efficient than collisions in changing the spin rates and obliquities of main belt asteroids with diameters $D < 40$ km. Additional studies of the Koronis family asteroids (Vokrouhlicky et al. 2006; Slivan et al. 2009) confirmed previously found clustering, although one stray object has also been found. The number of objects with known spin vector parameters within Koronis family is now 15.

Vokrouhlicky et al. (2003) investigated whether small asteroids in the other main belt regions, may also be trapped in Slivan states. They concluded that Slivan states may be found for low inclination asteroids in the outer main belt. A more complex spin-vector evolutionary path was obtained for inner main-belt asteroids. They also suggested making a careful comparison between numerical results and observations.

An observing campaign targeting small bodies in the outer main belt would require continuous access to the one-metre class or larger telescopes with efficient CCD cameras. Because of the lack of such dedicated instruments, we decided to concentrate our observing campaign on small bodies in the inner main belt, namely the Flora region. The location of this region makes its members available for photometric observations using relatively small telescopes. Thus, we were able to reach small objects, of diameters smaller than 30 km, which are sensitive to the influence of both Yarkovsky and YORP effects. The Flora family has more than 500 members and is unusually dispersed across proper eccentricity and inclination. It is intersected by several mean-motion resonances with Mars and Jupiter. Zappala et al. (1990, 1995) and Bendjoya (1993) used two different methods: hierarchical clustering (HCM) and wavelet analysis (WAM) of classification asteroids into families. Both methods are in good agreement in the resulting family classifications. The Flora dynamical family is the biggest in their analysis and has several denser groupings, which is in good accordance with the commonly suggested multi-collisional-event origin of this family. Most of the objects defined as the Flora family by HCM and/or WAM are S type and only two of them 8 Flora and 43 Ariadne have diameters larger than 30 km.

Mothe-Diniz et al. (2005) reanalysed the structure of asteroid families using visible spectroscopy. Their results indicate that most of the families are quite homogenous taxonomicaly and mineralogically and probably originated from homogenous parent bodies. Using the HCM mathod, Mothe-Diniz et al. (2005) divided the Flora region into Baptistina family objects plus several small clumps. However, the division into clumps and their size depends on the adopted cutoff parameter. Eventually, clumps will merge together but at the same time they will merge with Vesta family. Unfortunately only eight members of the Baptistina family have known spectra and six of them are different than S type. Taking into account groupings only, the Belgica clump has more than three members with known spectra and all the objects are of S type.

The latest family identification was done by Nesvorny (2010). Using HCM method and proper elements for 293 368 asteroids, he obtained 55 families. In this classification, the Flora family contains 10 437 members and belongs to the three most-abundant families. It is surprising that the large asteroid 9 Metis, whose diameter is even larger than that of 8 Flora, as well as 113 Amalthea and 376 Geometria, now belongs to this family. The largest objects, unaffected by the nongravitational effects, are not taken into account in this study.

Our observing campaign was devoted to all objects smaller than 30 km classified by HCM and/or WAM as Flora family members. Objects identified as binary systems, namely 809 Lundia, 939 Isberga, 1089 Tama, 1338 Duponta, 1830 Pogson, 1857 Parchomenko, 2121 Sevastopol, 2691 Sersic, 2815 Soma, 2478 Tokai, 3073 Kursk, and 3749 Balam, were not taken into account in this study.

2. Observations and data reduction

Because many of the periods of rotation for the Flora family asteroids have been reported by amateurs only, or have been based on low quality lightcurves, we decided to observe as many objects as possible. Our regular photometric observations of the Flora family asteroids started in 2002. However, some lightcurves were obtained by us before this year. In this paper, we report 544 individual lightcurves of 55 asteroids observed at fifteen observatories: Borowiec (Poland), Pic du Midi (France), National Astronomical Observatory, Rozhen (Bulgaria), Kharkov (Ukraine), South African Astronomical Observatory (South Africa), San Pedro de Atacama (Chile), Pico dos Dias (Brazil), Kielce (Poland), Poznan Observatory (Poland), Les Engarouines (France), Observatorio del Roque de los Muchatos (Spain), Haute-Provence Observatory (France), Le Cres (France), Bedoin Observatory (France), and Stazzione Astronomica di Sozzago (Italy). We note that we were limited only by the brightness of the observed objects and weather conditions.

Observations in Borowiec were carried out with a 0.4 m $F/4.5$ *Newton* reflector equipped with KAF400 and (since September 2009) KAF402ME CCD cameras and a set of Bessel *BVRI* and clear (C) filters. Details of the Borowiec

[1] www/astro.amu.edu.pl/Science/Asteroids

system are described in Michalowski et al. (2004). Some of the lightcurves from Borowiec were obtained using Poznan Spectroscopic Telescope (PST), which consists of parallel twin 0.5 m $f/4.5$ *Newton* telescopes on a single parallactic fork mount. Two KAF400 CCD cameras were mounted at the primary focus of both mirrors. Details of this telescope are described in Baranowski et al. (2007).

Lightcurves observed at Pic du Midi were obtained using the 1.05 m Cassegrain telescope equipped with THX 7863 CCD camera and *R*, DH, or *L* filters. Since October 2010, the Andor iKon-L 2048 × 2048 pixels CCD camera was used. A standard reduction for bias and flatfield of the Pic du Midi observations were done using Astrol package developed at IMCCE in Paris and Starlink package[2]. Observations from Borowiec were reduced for bias, dark current and flatfield using the Starlink package. The aperture photometry of Borowiec and Pic du Midi frames was carried out with the PHOTOM programme included in the Starlink package.

Observations at the National Astronomical Observatory at Rozhen were carried out with the 50/70 cm $f/3.44$ Schmidt telescope equipped with a KAF1602E 1530×1020 pixels CCD camera and Bessel *VR* filters, and with a 2 m RCC $f/8$ telescope equipped with a Photometrics CE200A 522 × 512 pixels CCD camera and *R* filter. For the data reduction and aperture photometry, IDL software was used.

Kharkov data were collected at the Grakovo Observing Station with the 0.7 m reflector. equipped with a IMG 1024S CCD camera and Johnson *UBVRI* filters. Data reduction was carried out using ASTPHOT software developed by Stefano Mottola (Mottola et al. 1995; Erikson et al. 2000).

Observations at South African Astronomical Observatory were done with the 0.76 m Cassegrain telescope and WRT1 420 × 289 pixel CCD camera in 2008 and 2009, and KAF1603ME 1530 × 1020 pixel CCD camera in 2010. Kielce observations were done using the 0.35 m Schmidt-Cassegrain reflector with the SBIG ST7XE CCD camera (KAF0401E chip) and C or *V* Bessel filter.

Observations at Pico dos Dias were carried out with the 0.6 m $f/12.5$ Zeiss telescope equipped with a EEV 400 × 290 pixels CCD, mounted at the Cassegrain focus and *R* filter.

San Pedro de Atacama data were collected with the CAO 0.4 m $F/7.7$ reflector and KAF1603ME, 1530 × 1020 pixel CCD camera clear filter.

Lightcurves from Observatorio del Roque de los Muchachos were produced using the 2.56 m Nordic Optical Telescope (NOT) and ALFOSC (The Andalucia Faint Object Spectrograph and Camera) with back-side illuminated EEV CCD camera and *R* filter.

Poznan Observatory lightcurves were obtained with a 0.7 m robotic Planewave CDK700 $f/6.6$ reflector, during its commissioning stage, equipped with Andor iXon back-side illuminated CCD and clear filter.

Data from SAAO, Kielce, Pico dos Dias, San Pedro de Atacama, Les Engarouines, NOT and Poznan were reduced for bias, dark current (not required for Andor cameras) and flatfield using Starlink package. Aperture photometry of all of the above mentioned data was carried out with PHOTOM programme included in Starlink package.

Details of the instruments used in Haute-Provence Observatory (France), Les Engarouines (France), Stazzione Astronomica di Sozzago (Italy), Le Cres Observatory (France), and Bedoin Observatory (France) can be found at the website of Geneva Observatory maintained by Raoul Behrend[3].

Most of the observed lightcurves have a scatter of points at a level of 0.01 mag with respect to the fitted fourth-order Fourier harmonics. Systematic effects caused by changes in the viewing geometry influence the shape of the observed lightcurves and the obtained synodic periods. Period determination was done using the procedure described by Magnusson & Lagerkvist (1990). In each case, the uncertainty in the period was determined by changing the value of the period to find the worst tolerable fit of the composite lightcurve. Because of this, the reported uncertainties of the periods are maximal errors rather than standard deviations. We note that the synodic period for a given asteroid may vary by typically up to 0.0005 h between apparitions. Because of that, making efforts to derive synodic periods with higher accuracy is of little importance. The reported lightcurves will be a good foundation for future spin-vector and shape determinations, which will appear in the second paper of the series. A description of individual objects as well as composite lightcurves and aspect data are available in Appendix A.

3. Properties of the the Flora asteroids

Observations of 55 individual Flora family objects resulted in 544 lightcurves. They yielded new or refined synodic periods for 32 objects and confirmed period determinations for 23 asteroids. To improve the statistics of the Flora family asteroids and avoid eventual observational bias, we added to our dataset 91 objects up to number 4150 having published secure non-ambiguous solutions for their periods based on the full lightcurve coverage (reliability/quality code $\geqq 3$, see Lagerkvist et al. 1989, or International Astronomical Union (IAU) Minor Planet Lightcurve Parameters). We searched the Asteroid Lightcurve Database[4] released on August 2011. Moreover, we checked the original sources where period determinations were reported. We also searched rotation curves of asteroids available at the website maintained by Raoul Behrend[5].

This process provided a total sample of 146 Flora asteroids with known synodic rotation-periods. Table 1 summarizes the physical data of our sample: diameters (D [km]), absolute magnitudes (H [mag]), maximum amplitudes of the observed lightcurves (A [mag]), a geometric albedo (p_v), the synodic period of rotation (P [h]), a frequency of rotation (f [1/d]), a taxonomic type, and classification to the family by HCM and WAM. Objects observed within this survey are marked in boldface. Most of the diameters and geometric albedos are taken from AcuA (Asteroid Catalog Using AKARI/IRC mid-infrared survey, Usui et al. 2011). They are marked with ^{A}. The other diameters are calculated from MPC absolute magnitudes and albedo using the standard formula $D = 1329 \times 10^{(-H/5)} \times p_V^{(-1/2)}$ (Fowler & Chillemi 1992; Pravec & Harris 2007). Families in the main belt are quite homogenous taxonomically (Cellino et al. 2002; Mothe-Diniz et al.2005). Most of the objects identified as the Flora family are of taxonomic S-type. We calculated an average albedo for S-type objects from AcuA for 65 Flora family objects contained in Table 1. This average value of albedo of 0.25 is assumed for the other S-type asteroids and for objects with unknown taxonomic type. For three C-type objects (1523 Pieksamaki, 2093 Genichesk, 2283 Bunke) we assumed an albedo of 0.057. For D-type 827 Wolfiana we

[2] http://starlink.jach.hawaii.edu/starlink

[3] http://obswww.unige.ch/~behrend/page_cov.html

[4] http://www.minorplanet.info/lightcurvedatabase.html

[5] http://obswww.unige.ch/~behrend/page1cou.html

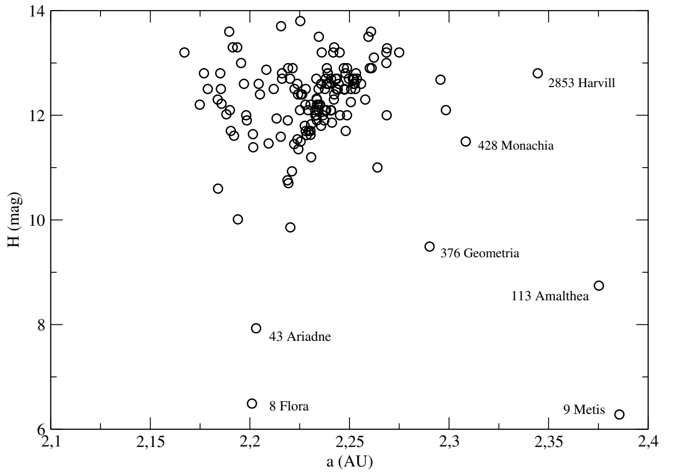

Fig. 1. Absolute magnitude *H* (mag) as a function of semimajor axis *a* (AU) for 146. Flora family asteroids.

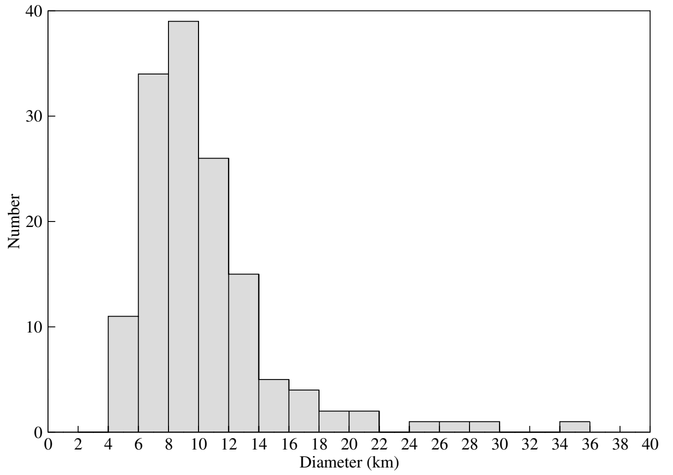

Fig. 2. Histogram of the diameters of the Flora family objects from our sample, the largest objects 8 Flora (138 km), 9 Metis (166 km), 43 Ariadne (59 km), and 113 Amalthea (46 km) are excluded.

assumed an albedo of 0.04 and 0.15 for X-type 3533 Toyota. Taxonomic types given in Table 1 are taken from the collection of asteroid taxonomic classifications from various classification methods, collected from the literature (Neese 2010) and are indicated with [1]. Types from the SDSS-based Asteroid Taxonomy (Hasselman et al. 2011) are marked with [2] and from Alvarez-Candal et al. (2006) are marked with [3]. Maximum lightcurve amplitudes for objects not observed within this survey are taken from the Asteroid Lightcurve Database [4] version released on August 2011.

In the last three columns of Table 1, we present the membership to the family with specifications of the family identification technique: HCM – Zappala et al. (1995), WAM – Bendjoya (1993), Zappala et al. (1995), and HCM 2010 – Nesvorny (2010).

Only 8 Flora, 9 Metis, 43 Ariadne, and 113 Amalthea have diameters larger than 40 km. 9 Metis, 113 Amalthea, and 376 Geometria appear as Flora-family objects only in the latest family identification – HCM 2010. Figure 1 shows that these objects, especially 9 Metis and 113 Amalthea, as well as 376 Geometria, 428 Monachia, and 2853 Harvill are far from the main grouping of the family. A histogram of the diameters of the

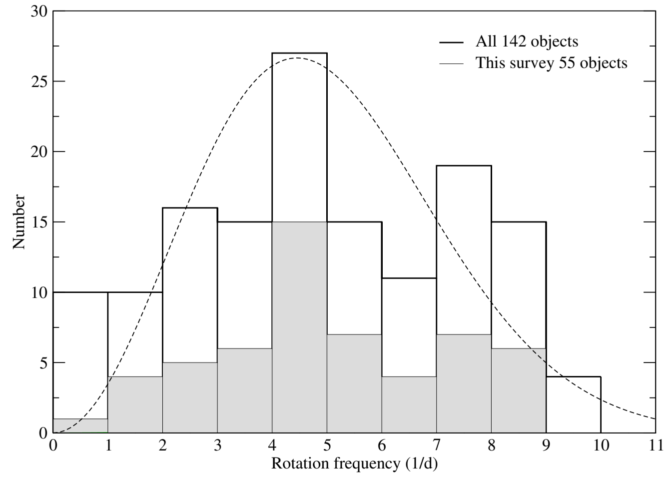

Fig. 3. Solid line – observed rotation-rate distribution for 142 objects of the Flora family. Asteroids observed within this campain are marked in grey. The dashed curve represents the Maxwellian distribution, for a mean squared frequency of 5.47 1/d, which is inconsistent with the sample at the 94% confidence level. The asteroids 8 Flora, 9 Metis, 43 Ariadne and 113 Amalthea are excluded.

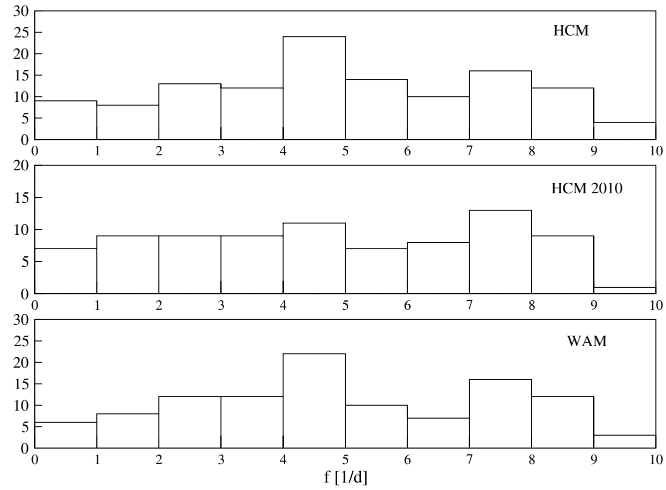

Fig. 4. Observed rotation-rate distribution for objects of the Flora family classified by different methods. 8 Flora, 9 Metis, 43 Ariadne, and 113 Amalthea are excluded.

objects used in this study is presented in Fig. 2. The majority of the studied objects have diameters from 6 km to 14 km.

The observed rotation-rate distribution for 142 asteroids smaller than 35 km is presented in Fig. 3 (solid line). The grey columns represent the rotation-rate distribution for 55 objects observed within this study. The distribution is qualitatively similar to the statistics when extended to 142 objects. The only differences are visible for the fastest and the slowest rotators. We did not observe objects rotating faster than 9 cycles per day. For four very slow rotators observed by us, the dataset was insuffcient to obtain a unique solution for their periods. From this reason these objects did not appear in the first bin of the histogram presented in Fig. 3. This also explains the discrepancy between the number of objects of our and the extended sample in the first bin of the histogram. These four objects however are less than 7% of our sample and are not of crucial importance.

The dashed curve represents the Maxwellian distribution for the mean squared spin frequency of 5.47 d^{-1}. The Kolmogorov-Smirnov one sample test made with *Mathematica* confirms that

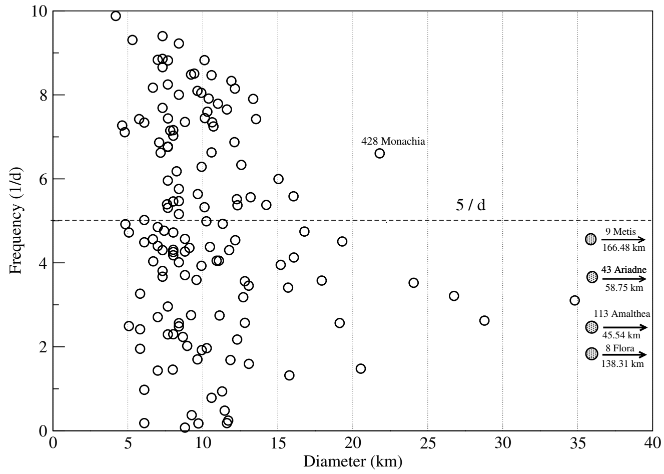

Fig. 5. Relation between frequency of rotation and diameter for 146 Flora family objects. All objects larger than 16 km rotate slower than 5 cycles per day. Smaller objects present all possible variety of frequencies.

the distribution of rotation rates in the Flora family is inconsistent with a Maxwellian distribution at a confidence level of 94%. We see an excess of fast and slow rotators and a peak around 4–5 rotations per day, which might still be connected with the original spin rate of the family parent body.

The observed rotational rate distribution does not depend on the classification method, Fig. 4. The asteroid sample for HCM 2010 is less abundant but the distribution is qualitatively similar. We also checked whether possible interlopers namely objects with other than a S taxonomic type, may influence the spin rate distribution. The result was negative.

Figure 5 presents the relation between the frequency of rotation and the diameter for 146 Flora family asteroids. All objects larger than 16 km rotate slower than five cycles per day. Objects smaller than 16 km have all possible frequencies. The only exception is the X-type asteroid 428 Monachia.

4. Discussion

A collisionaly evolved asteroid population should have a Maxwellian distribution of spin rates (Salo 1987). This behaviour is observed for objects with $D > 40$ km (Pravec et al. 2002 and references therein). The distribution of the spin rates of small asteroids (with 0.15 km $< D <$ 10 km) is strongly non-Maxwellian with a significant excess of fast and slow rotators. The smallest main-belt/Mars-crossing asteroids with diameters 3 km $< D <$ 15 km have a uniform distribution of frequencies from 1 d^{-1} to 9.5 d^{-1} and a strong excess of slow rotators for frequencies lower than 1 d^{-1}, owing to the YORP effect (Pravec et al. 2008). Pravec et al. (2002) did not study in detail the transitional region where groups of large and small asteroids overlap. Some objects in this diameter range are members of the dynamical families.

The distribution of spin rates in the Flora family presented in Fig. 3 differs significantly from the distribution reported for the Koronis family by Slivan et al. (2008) and the Hungaria family by Warner et al. (2009b). Flora family asteroids do not have such a strong excess of slow rotators as the two other families. The dynamical evolution of the Flora family was studied by Nesvorny et al. (2002). They concluded that the age of the Flora family is significantly younger than 1 Gyr or even 0.5 Gyr. Cratering on 951 Gaspra suggests an even younger age of 200 Myr for the Flora family (Chapman 2002). The above-mentioned values are significantly younger than the age of the Koronis family 2–3 Gyr based on either the cratering of 243 Ida (Chapman 2002) or dynamical simulations (Vokrouhlicky et al. 2003 and references therein). The Hungaria dynamical family is younger than Koronis and its age is estimated to be about 0.5 Gyr (Warner et al. 2009b).

If we assumed that the spin rates are modified by nongravitational forces such as the YORP effect in the case of Flora clan, it would have had much less time to leave its fingerprint. The spin rate distribution confirms that Flora is younger than both the Koronis and Hungaria families.

In the following paper, we continue our study of the possible influence of the YORP effect on the spin axes of Flora family asteroids. We search for spin vector and spin period correlations to dermine whether Slivan States exist in the Flora family.

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Table 1. Physical data of the Flora family asteroids.

Asteroid	D[km]	H[mag]	A[mag]	p_v	P[h]	f[1/d]	Type	HCM	WAM	HCM 2010
8 Flora	138.31^A	6.49^A	0.11	0.235^A	12.865	1.8655	S, Sw [1]	+	+	+
9 Metis	166.48^A	6.28^A	0.36	0.213^A	5.079	4.7253	S [1]			+
43 Ariadne	58.75^A	7.93^A	0.66	0.347^A	5.762	4.1652	S, Sk, Sq [1]	+	+	+
113 Amalthea	45.54^A	8.74^A	0.20	0.273^A	9.935	2.4157	S [1]			+
244 Sita	11.60^A	12.20^A	0.82	0.176^A	129.51	0.1853	Sa, Sw [1]	+		
281 **Lucretia**	12.27^A	12.02^A	0.30	0.185^A	4.349	5.5183	SU [1]	+	+	
291 **Alice**	13.19^A	11.45^A	0.50	0.270^A	4.316	5.5607	S [1]	+	+	
298 **Baptistina**	20.53^A	11.00^A	0.15	0.170^A	16.23	1.4787	X, Xc [1]	+	+	+
315 Constantia	6.089	13.20	0.57	0.25	5.345	4.4902	–	+	+	
352 **Gisela**	26.76^A	10.01^A	0.66	0.249^A	7.4796	3.2087	S,Sl, S0, Sw [1]	+	+	+
364 **Isara**	28.78^A	9.86^A	0.65	0.244^A	9.1570	2.6209	S, S0 [1]	+		+
367 **Amicitia**	16.78^A	10.70^A	0.70	0.343^A	5.055	4.7478	S [3]		+	
376 Geometria	34.80^A	9.49^A	0.19	0.235^A	7.734	3.1032	S [1,2]			+
428 **Monachia**	21.79^A	11.50^A	0.25	0.097^A	3.6342	6.6039	X [3]	+		+
453 **Tea**	24.07^A	10.60^A	0.12	0.176^A	6.811	3.5237	S [1]	+	+	
540 **Rosamunde**	19.12^A	10.76^A	0.60	0.265^A	9.349	2.5671	S [1]	+	+	+
553 Kundry	9.93^A	12.20^A	0.52	0.237^A	12.381	1.9200	S [1]	+	+	+
685 **Hermia**	11.46^A	11.80^A	0.90	0.280^A	50.40	0.4768	S [1]	+	+	+
700 **Auravictrix**	15.19^A	11.20^A	0.44	0.263^A	6.075	3.9506	S [1,3]	+	+	+
711 **Marmulla**	11.90^A	11.90^A	0.04	0.224^A	2.88	8.3333	A [3]	+	+	+
728 Leonisis	7.32	12.80	0.20	0.25	5.5783	4.3024	A,S [1,2]	+	+	+
736 Harvard	17.92^A	11.64^A	0.32	0.122^A	6.7	3.5821	S [1]		+	
770 **Bali**	16.07^A	10.93^A	0.65	0.304^A	5.8199	4.1238	S [1]		+	
800 **Kressmannia**	14.23^A	11.61^A	0.34	0.202^A	4.4610	5.3794	S [1]	+	+	+
802 **Epyaxa**	8.027	12.60	0.70	0.25	4.392	5.4645	–	+	+	
810 Atossa	8.405	12.50	0.55	0.25	4.385	5.4732	A [3]	+		
825 **Tanina**	13.06^A	11.50^A	0.50	0.278^A	6.9398	3.4583	SR,S [1]	+	+	
827 **Wolfiana**	15.04	13.20	0.19	0.041	4.0	6.0000	D [3]	+		+
836 Jole	5.06	13.6	0.37	0.25	9.615	2.4961	S [2]			+
841 **Arabella**	8.027	12.60	0.25	0.25	3.352	7.1599	–	+	+	+
851 Zeissia	12.81^A	11.62^A	0.38	0.248^A	9.34	2.5696	S [1]	+	+	
864 **Aase**	5.76^A	12.87^A	0.20	0.378^A	3.2325	7.4246	S [1]	+	+	
883 Matterania	8.027	12.60	0.42	0.25	5.64	4.2553	S [1]	+	+	+
901 Brunsia	11.61^A	11.35^A	0.27	0.480^A	3.136	7.6523	S [1]	+		
905 **Universitas**	11.84^A	11.59^A	0.28	0.30^A	14.238	1.6856	S [1]	+	+	+
913 **Otila**	11.32^A	11.90^A	0.10	0.245^A	4.8719	4.9262	Sa, Sw [1]	+	+	+
915 **Cosette**	12.31^A	11.70^A	0.52	0.247^A	4.4702	5.3690	S [1,3]	+	+	+
929 Algunde	10.70^A	12.10^A	0.14	0.242^A	3.310	7.2503	S, Sl [1]	+	+	+
935 Clivia	7.18^A	12.90^A	0.13	0.247^A	3.6222	6.6258	–	+		+
937 **Bethgea**	12.69^A	11.83^A	0.20	0.203^A	7.539	3.1834	S [1]	+	+	
951 Gaspra	15.68^A	11.46^A	1.00	0.189^A	7.0420	3.4081	S [1]	+	+	+
956 Elisa	8.00	12.1	0.36	0.4	16.50	1.4545	V [1]			+
960 **Birgit**	6.991	12.90	0.27	0.25	8.85	2.7119	A [3]	+		
963 Iduberga	10.38^A	12.49^A	0.34	0.165^A	3.0341	7.9101	S [1]	+	+	
967 **Helionape**	13.55^A	12.10^A	0.13	0.142^A	3.232	7.4257	–	+	+	+
1016 **Anitra**	11.08	11.90	0.28	0.25	5.9288	4.0480	S [1]	+	+	+
1047 Geisha	11.29	11.86	0.33	0.25	25.62	0.9368	S[1], LS[2]		+	+
1055 **Tynka**	8.95^A	12.00^A	0.09	0.35^A	11.893	2.0180	S [1]	+	+	
1056 **Azalea**	13.07^A	11.70^A	0.72	0.223^A	15.03	1.5968	S [1]	+	+	+
1060 **Magnolia**	7.665	12.70	0.25	0.25	2.9108	8.2452	S [1,2]	+	+	+
1088 **Mitaka**	13.35^A	11.39^A	0.62	0.276^A	3.0353	7.9070	S [1]	+	+	
1117 **Reginita**	12.149	11.70	0.30	0.25	2.9464	8.1455	S [1,2]		+	
1120 Cannonia	9.920^A	12.80^A	0.16	0.137^A	3.816	6.2893	–	+		
1130 **Skuld**	10.24^A	12.10^A	0.53	0.244^A	4.8079	4.9918	S,Sl [1]	+	+	
1133 **Lugduna**	10.47^A	12.22^A	0.45	0.208^A	5.478	4.3812	S [1]	+	+	
1185 Nikko	12.56^A	12.09^A	0.50	0.164^A	3.79	6.3324	S [1]	+	+	+
1188 **Gothlandia**	12.11^A	11.70^A	0.70	0.252^A	3.4917	6.8734	S [1]	+	+	+
1219 **Britta**	11.76^A	11.94^A	0.73	0.223^A	5.5750	4.3049	S [1]	+	+	
1225 Ariane	9.10^A	12.10^A	0.36	0.308^A	5.5068	4.3582	–	+	+	
1249 **Rutherfordia**	15.77^A	11.54^A	0.65	0.1720^A	18.220	1.3172	S [1]	+	+	+
1270 Datura	7.83^A	12.50^A	0.61	0.291^A	3.359	7.1450	S [3]	+	+	+
1307 Cimmeria	9.43	12.25	0.31	0.25	2.820	8.5106	S [1]	+	+	+
1314 Paula	6.7^A	12.68^A	0.83	0.377^A	5.9498	4.0337	S [1]	+	+	+
1324 Knysna	7.32	12.80	0.08	0.25	2.5538	9.3978	Sq [1]	+	+	

Table 1. continued.

Asteroid	D[km]	H[mag]	A[mag]	p_v	P[h]	f[1/d]	Type	HCM	WAM	HCM 2010
1344 Caubeta	7.32	12.80	0.21	0.25	3.1220	7.6874	S [2]	+	+	
1376 **Michelle**	8.405	12.50	0.20	0.25	5.9769	4.0155	–	+	+	
1396 Outenniqua	11.00^A	12.00^A	0.42	0.237^A	3.081	7.7897	S, Sl [1]		+	
1418 Fayeta	9.25^A	12.09^A	0.24	0.305^A	63.641	0.3771	–	+		+
1446 Sillanpaa	8.41	12.50	0.55	0.25	9.659	2.4847	LS [2]	+	+	+
1449 Virtanen	10.581	12.00	0.69	0.25	30.495	0.7870	S, Sl [1]	+	+	+
1451 Grano	9.7^A	12.60^A	0.65	0.171^A	138.0	0.1739	S [2]	+	+	+
1472 Muonio	9.216	12.30	0.48	0.25	8.706	2.7567	–	+	+	
1496 Turku	8.801	12.40	0.51	0.25	6.47	3.7094	–	+	+	
1514 Ricouxa	8.027	12.60	0.62	0.25	10.438	2.2993	–		+	+
1518 Rovaniemi	8.801	12.40	0.25	0.25	5.249	4.5720	S [1]	+	+	+
1523 **Pieksamaki**	19.30	12.30	0.46	0.057	5.3202	4.5111	C [3]	+	+	+
1527 Malmquista	9.65	12.20	0.54	0.25	14.077	1.7049	S [2]	+		+
1562 **Gondolatsch**	11.12^A	11.80^A	0.42	0.283^A	8.74	2.7460	S [1]	+	+	+
1590 **Tsiolkovskaja**	12.81^A	11.70^A	0.30	0.232^A	6.7299	3.5662	–	+	+	+
1601 **Patry**	10.93^A	12.32^A	0.72	0.178^A	5.92	4.0541	Sl [1]	+	+	+
1602 Indiana	8.410^A	12.49^A	0.17	0.259^A	2.601	9.2272	S [1]	+	+	
1619 **Ueta**	10.105	12.10	0.35	0.25	2.7180	8.8300	S [1,2]	+		+
1621 Druzhba	11.7^A	11.63^A	0.75	0.312^A	99.20	0.2419	S [2]	+		+
1622 Chacornac	10.27^A	12.2^A	0.25	0.224^A	12.206	1.9662	S [1]	+	+	+
1631 Kopff	9.580^A	12.20^A	0.41	0.259^A	6.683	3.5912	–	+	+	
1636 Porter	9.65	12.20	0.22	0.25	2.9653	8.0936	S [1]	+	+	+
1666 Van Gent	8.405	12.50	0.30	0.25	4.166	5.7609	–	+		+
1667 **Pels**	10.62^A	12.10^A	0.25	0.232^A	3.2681	7.3437	Sa, Sw [1]			+
1675 **Simonida**	12.16^A	11.90^A	0.58	0.211^A	5.2885	4.5381	–	+	+	+
1682 **Karel**	4.80^A	12.90^A	0.47	0.531^A	3.3750	7.1111	–	+	+	+
1696 Nurmella	10.31^A	12.9^A	0.42	0.146^A	3.1587	7.5981	–	+	+	+
1738 Oosterhoff	7.62^A	12.30^A	0.54	0.370^A	4.4486	5.3950	S [1]	+	+	
1785 Wurm	6.089	13.20	0.29	0.25	3.2693	7.3410	S [1]	+	+	+
1790 Volkov	8.670^A	12.50^A	0.09	0.241^A	10.742	2.2342	–	+	+	+
1793 **Zoya**	8.027	12.60	0.72	0.25	5.74	4.1812	S, Sl [1]	+		
1806 Derice	10.14^A	12.00^A	0.19	0.282^A	3.2240	7.4442	S, Sl [1]	+	+	+
1807 Slovakia	8.801	12.40	1.00	0.25	308.0	0.0779	S, Sqw [1]	+		
1829 Dawson	9.67^A	12.50^A	0.28	0.189^A	4.254	5.6417	S [2]	+		+
1855 Korolev	8.405	12.50	0.75	0.25	4.65	5.1613	–	+	+	+
1967 Menzel	10.58	12.00	0.27	0.25	2.835	8.4656	S [1,3]	+		
2017 **Wesson**	8.027	12.60	0.61	0.25	3.4158	7.0262	S,X [1,3]	+	+	+
2036 **Sheragul**	7.0^A	12.70^A	0.71	0.30^A	5.45	4.4037	A [2]		+	
2080 Jihlava	7.32	12.80	0.15	0.25	2.7088	8.8600	–		+	
2093 Genichesk	12.29	13.28	0.24	0.057	11.028	2.1763	C [1]	+	+	+
2094 Magnitka	9.910^A	12.00^A	0.86	0.285^A	6.11	3.9280	–	+	+	+
2156 **Kate**	8.801	12.40	0.91	0.25	5.623	4.2682	A [1,2]	+		
2175 Andrea Doria	4.84	13.7	0.25	0.25	4.88	4,9180	S [2]	+		
2283 **Bunke**	16.05	12.70	0.07	0.057	4.3	5.5814	C [2]		+	
2341 Aoluta	8.41	12.5	0.25	0.25	2.998	8.0053	S, Sl [1]	+		
2438 Oleshko	7.67	12.7	0.19	0.25	3.227	7.4372	S [1]	+		+
2445 Blazhko	10.581	12.00	0.57	0.25	3.6197	6.6304	S [2,3]	+	+	+
2460 **Mitlincoln**	9.216	12.30	0.20	0.25	2.8277	8.4875	L [2]		+	
2510 Shandong	7.09^A	12.60^A	0.44	0.345^A	3.4963	6.8644	S [1]		+	+
2609 Kiril-Metodi	7.0	12.9	0.8	0.25	4.9433	4.8551	–	+	+	+
2647 Sova	8.405	12.50	0.35	0.25	9.366	2.5625	–	+	+	+
2665 Schrutka	7.0	12.9	0.25	0.25	2.7170	8.8333	–	+	+	+
2709 Sagan	6.676	13.00	0.36	0.25	5.258	4.5645	S [1]	+		
2768 Gorky	10.105	12.10	0.51	0.25	4.507	5.3250	A [3]	+	+	+
2839 Annette	7.665	12.70	0.92	0.25	10.457	2.2951	–		+	
2841 Puijo	7.665	12.70	0.03	0.25	3.545	6.7701	S, Sk [1]	+	+	+
2853 Harvill	7.32	12.8	0.65	0.25	6.30	3.8095	–			+
2874 Jim Young	6.09	13.2	0.75	0.25	131.3	0.1828	S [1]	+	+	+
2887 Krinov	6.99	12.9	0.65	0.25	16.71	1.4363	S [2]	+	+	+
2961 **Katsurahama**	6.676	13.0	0.28	0.25	2.937	8.1716	S [1]	+	+	+
3059 Pryor	6.09	13.2	0.6	0.25	24.544	0.9778	S, LS[2]	+	+	
3105 Stumpff	7.430^A	13.10^A	0.35	0.185^A	5.0369	4.7648	S, Sl [1]	+	+	
3144 Brosche	4.619	13.80	0.60	0.25	3.30	7.2727	–		+	+
3165 Mikawa	8.027	12.60	0.25	0.25	5.100	4.7244	S [2]	+	+	+
3410 Vereshchagin	5.303	13.50	0.10	0.25	2.5780	9.3095	S [2]	+	+	+

Table 1. continued.

Asteroid	D[km]	H[mag]	A[mag]	p_v	P[h]	f[1/d]	Type	HCM	WAM	HCM 2010
3411 Debetencourt	5.815	13.30	0.43	0.25	9.93	2.4169	–	+	+	
3455 Kristensen	7.665	12.70	0.38	0.25	8.111	2.9589	–	+		
3533 Toyota	9.90	12.70	0.18	0.15	2.981	8.0510	Xk, X [1,2]	+	+	+
3573 Holmberg	7.320	12.80	1.03	0.25	6.5431	3.6680	S, Sr [1,2]	+		+
3605 Davy	7.67	12.7	0.25	0.25	2.72	8.8235	–	+	+	+
3640 Gostin	8.8	12.4	0.4	0.25	3.2641	7.3527	S [1]	+	+	+
3722 Urata	8.027	12.60	0.58	0.25	5.5670	4.3111	–	+	+	
3763 Qianxuesen	8.260[A]	12.50[A]	0.31	0.259[A]	3.884	6.1792	L [2]	+	+	
3813 Fortov	5.82	13.3	0.76	0.25	12.3	1.9512	S [1]		+	
3825 Nurnberg	7.665	12.70	0.71	0.25	4.030	5.9553	–	+	+	+
3831 Pettengill	6.09	13.2	0.58	0.25	4.78	5.0209	S [1,2]	+		
3850 Peltier	4.19	13.50	0.10	0.40	2.4289	9.8810	V [1]	+		
3953 **Perth**	5.064	13.60	0.92	0.25	5.083	4.7216	–	+		
3956 Caspar	7.32	12.80	0.13	0.25	2.7707	8.6621	–	+	+	
3986 **Rozhkovskij**	7.665	12.70	0.35	0.25	3.5493	6.7619	–	+	+	
4080 Galinskij	5.815	13.30	1.01	0.25	7.35	3.2653	–	+	+	+
4150 **Starr**	7.665	12.70	0.21	0.25	4.5179	5.3122	S [2,3]	+		

Notes. Objects observed within this survey are marked in boldface, [(A)] indicates data from AcuA, diameters if not given by AcuA are calculated from the MPC absolute magnitude H and albedo, taxonomic types from (Neese 2010) are indicated with [(1)], types from the SDSS-based Asteroid Taxonomy (Hasselman et al. 2011) are marked with [(2)], and those from Alvarez-Candal et al. (2006) are marked with [(3)].

Appendix A: Description of the individual cases

Here we present in detail the results of our observing campaign. All the observed objects are fully described. Composite lightcurves are folded with periods determined and checked during this study. Aspect data for all of the observed lightcurves are available in Table A.1. Columns give dates of observations with respect to the middle of the lightcurve, asteroid distances to the Sun (r) and the Earth (Δ) in AU, phase angle (α), observer-centred ecliptic longitude (λ) and latitude (β) for J2000.0, and the observatory code (Obs).

A.1. 281 Lucretia

Taylor et al. (1976) reported photometric observations of Lucretia from 1969, 1972, and 1974. They obtained a synodic period of 4.348 h and concluded that the spin axis of Lucretia is nearly perpendicular to the ecliptic.

We observed Lucretia on nine nights during four oppositions in 2003, 2006, 2008/2009, and 2011 in Borowiec and Rozhen. Our synodic period of 4.349 ± 0.001 h confirms Taylor's et al. determination. All the lightcurves observed for this asteroid have similar amplitudes of 0.30–0.40 mag, implying that the spin vector has a high latitude. Our composite lightcurves are presented in Figs. A.1–A.4.

A.2. 291 Alice

The first preliminary model of 291 Alice published by Kryszczynska et al. (1996) was based on only six lightcurves from three oppositions in 1974 (Lagerkvist 1978), 1981 (Binzel & Mulholland 1983) and 1994 (Kryszczynska et al. 1996). Subseqent observations of this object from three nights in February 1996 were reported by Piironen et al. (1998). These data are rather sparse and no attempt to the asteroid modelling was made in that paper. All of the above-mentioned papers gave the same synodic period of 4.32 h for Alice. Oey (2006) observed Alice on three nights in 2006 and obtained a period of 4.313 h. Ruthroff (2009) observed Alice on four nights in 2009 and obtained a period of 4.32 h Single lightcurves from 2009 and 2010 available at[6] have periods of 4.28 h and 4.30 h.

Our observations of Alice were done during four apparitions in 1999 (Fig. A.5), 2004 (Fig. A.6), 2007 (Fig. A.7), and 2009 (Fig. A.8) at Pic du Midi and Borowiec. We obtained ten new dense lightcurves at four different observing geometries. The improved value of synodic period of 4.316 ± 0.001 h closely fits all of our observations, as well as all the old data.

A.3. 298 Baptistina

The first photometric observations of Baptistina were done by Wisniewski et al. (1997) on a single night in 1989. They deduced a possible period of about 7 h for this object. Ditteon & Hawkins (2007) observed Baptistina on two consecutive nights in 2006 and obtained a period of 9.301 h.

Bottke et al. (2007) suggested that the parent body of the asteroid Baptistina underwent collisional disruption about 160 Myr ago. The resulting fragments formed a family that partially overlaps with the Flora family. Small fragments with diameters smaller than 40 km affected by the Yarkovsky and YORP effects and resonaces, evolved inward to the vicinity of the Earth and might be the most likely source of the Chicxulub impactor or even Tycho crater on the Moon. This scenario indeed encouraged the initial interest of observers in Baptistina itself.

Majaess et al. (2009) observed this asteroid in March and April 2008, and Carvano & Lazarro (2010) in March and May 2008. Majaess et al. obtained a best fit to the period of 16.23 h. Lightcurve composites with a period of 16.24 h produced by Carvano & Lazzaro shows that there is a significant shift for one lightcurve (see Fig. 2 in their paper).

We also observed Baptistina on three nights in May 2008. Because lightcurves from three nights only were insufficient for the period determination, we used the May data of Carvano & Lazzaro and April data from the Hunters Hill Observatory (included in Majaess et al. paper) available at the IAU Minor Planet Center website to improve the period determination. The lightcurve presented in Fig. A.9 was folded with the most-likely period of 16.23 ± 0.01 h and confirms Majaess et al. determination. This period also closely fits the Warner's (2010) observations from eight nights in Oct. and Nov. 2009 available at IAU MPC website.

A.4. 352 Gisela

The first photographic photometry of this object obtained by Lagerkvist in 1973 (Lagerkvist 1978) allowed them to estimate the 6.7 h period. Riccioli et al. (2001) observed Gisela on two consecutive nights in Aug. 1992 and obtained a period of 5.560 h from a very sparse dataset. Lazar et al. (2001) observed Gisela on three consecutive nights in Dec. 1999 and obtained a period of rotation of 7.49 h.

We observed Gisela on 19 nights during five apparitions in 2004, 2005, 2007, 2008, and 2010 in Borowiec, Rozhen, Pic du Midi, Les Engarouines, and Kielce. The synodic period fitted to our dataset is 7.4796 ± 0.0002 h. Composite lightcurves shown in Figs. A.10–A.14 have a range of different amplitudes from 0.1 mag in 2004 to 0.7 mag in 2010, which are caused by different viewing geometries.

A.5. 364 Isara

Yang et al. (1965) observed Isara in 1964 and obtained a period of 9.155 h. The lightcurve from two consecutive nights in Apr. 2009 available at[7] have a period of 9.151 h. Warner (2009b) observed Isara in Apr. 2009, obtaining a period of 9.156 h.

We observed Isara on 16 nights in 2005, 2006 and 2009 in Borowiec. To get the closest possible fit of the period, we used the data of Warner from Apr. 2009 (which are available at the IAU MPC website) together with our data from 2009. The final period for Isara is about 9.1570 ± 0.0003 h. The lightcurves of Isara from the 2009 apparition resemble the lightcurves of binary asteroids and may be indicative of a contact binary shape for this object. Composites are presented in Figs. A.15–A.17.

A.6. 367 Amicitia

This object was observed for the first time by Wisniewski et al. (1997) on two nights in 1992. The reported period of 4.209 h was not a unique solution and appeared to be wrong. Lightcurves from three nights in 2005 and one night in 2008 available at[8] are folded with periods of 5.055 h and 5.05 h, respectively.

[6] http://obswww.unige.ch/~behrend/r000291a.png and r000291e.png

[7] http://obswww.unige.ch/~behrend/r000364a.png

[8] http://obswww.unige.ch/~behrend/r000367a.png and r000364e.png

Our 15 lightcurves were obtained at various geometries in 2000 (Fig. A.18), 2003 (Fig. A.19), 2005 (Fig. A.20), 2008 (Fig. A.21), 2009 (Fig. A.22), and 2010 (Fig. A.23) at the Borowiec, Pic du Midi, Rozhen, and San Pedro de Atacama observatories. The derived period of 5.055 ± 0.001 h closely fits to the whole dataset.

A.7. 428 Monachia

Wisniewski et al. (1997) observed Monachia on seven nights from September untill December 1988 and obtained a period of 3.63384 ± 0.00002 h. Its lightcurve[9] is folded with the period of 3.6335 h.

We observed Monachia on only three nights during two apparitions in 2009 (Fig. A.24) and 2011 (Fig. A.25) in Borowiec. The composite lightcurve based on Wisniewski et al. data constructed with a period of 3.63384 is not convincing. The best fit we obtained for a synodic period of 3.6342 ± 0.0002 h. Our lightcurves confirm the above determination.

A.8. 453 Tea

Wisniewski et al. (1997) observed the asteroid Tea in 1990 and estimated a period of rotation of 6.4 h from just a single lightcurve. Lightcurves available at[10] observed in 2001 and 2008 are rather noisy. They have about a 1 h longer period of 7.32 h and 7.56 h. Licchelli (2006) observed 453 Tea on four nights in 2006 and obtained a period of 6.812 ± 0.001 h.

We observed Tea during five apparitions in 2005, 2006, 2008, 2010, and 2011 and obtained 17 lightcurves. Composites presented in Figs. A.26–A.30 were folded with the best-fit period of 6.811 ± 0.001 h. They have very different shapes and amplitudes ranging from 0.45 mag in 2005 to less than 0.1 mag in 2010 and 2011, which are caused by the different viewing geometries. Our data confims the period derived by Licchelli. This period laso fits the Wisniewski et al. data.

A.9. 540 Rosamunde

Wisniewski et al. (1997) observed Rosamunde on three nights in 1989 and obtained a period of 9.336 h. Lightcurves of this objects from 2005 and 2009 reported by Behrend[11] have periods of 9.3495 h and 9.342 h, respectively.

We observed Rosamunde during five apparitions in 2004 (Fig. A.31), 2007 (Fig. A.32), 2009 (Fig. A.33), 2010 (Fig. A.34), and 2012 (Fig. A.35) in Borowiec and Kielce and obtained 11 high-quality lightcurves. The synodic period fitted to our dataset is 9.351 ± 0.001 h. This value also fits the Wisniewski et al. data.

A.10. 685 Hermia

Hermia was a target of a large observing campaing during its 2006 apparition. The first lightcurves obtained in Borowiec suggested that this object might have a lightcurve of a synchronous binary system. Observations were carried out at the Hautes Provence Observatory (France), Stazzione Astronomica di Sozzago (Italy), Le Cres Observatory (France), Les Engarouines (France), and Bedoin Observatory (France). Unfortunately, the minima of the observed lightcurves were too broad for a detached binary system. The shape and 1 mag amplitude of the lightcurve based on 29 observing nights suggest that this object is probably a slowly rotating contact binary. The synodic period of rotation is 50.40 ± 0.05 h. The composite lightcurve is presented in Fig. A.36.

A.11. 700 Auravictrix

The first photometric observations of this object were done by Lagerkvist (1979) in Aug. 1977. The estimated period of 6 h appeared to be correct despite the significant amount of noise in the observed photographic data.

Our observations of 16 lightcurves carried out in 2003, 2004, 2006, 2007, 2008/2009, and 2011 apparitions in Borowiec and Rozhen are presented in Figs. A.37–A.42. They confirm a synodic period of 6.075 ± 0.001 h reported by Behrend[12].

A.12. 711 Marmulla

Wisniewski et al. (1997) observed this object on a single night in Jan. 1990 and found no apparent periodicity, probably because of the too large scatter in the data points of the lightcurve.

We observed 711 Marmulla during a 2009 apparition in Borowiec and Pic du Midi and got three lightcurves of extremely low amplitudes of 0.05 mag Fig. A.43. The synodic period of 2.88 ± 0.12 h was fitted to our dataset. Its very low amplitude is idicative of the nearly spherical shape of this object and/or pole-on view.

A.13. 770 Bali

Bali was observed by Wisniewski et al. (1997) on two nights in 1989. They derived a period of 5.9513 ± 0.0004 h. The lightcurves of Bali from 2007 and 2009 reported by Behrend[13] have periods of 5.8194 h and 5.8192 h, respectively.

We observed Bali during five apparitions in 2004, 2007, 2008, 2009/2010, and 2011 at Borowiec, Pic du Midi, and SAAO and obtained 19 lightcurves presented in Figs. A.44–A.48. The period of 5.8199 ± 0.0001 h that closely fits all our observations, is based on a six-month time span in 2009/2010 apparition. This value perfectly fits the Wisniewski et al. data and solves the problem of the full-cycle ambiguity between the only two observed lightcurves.

A.14. 800 Kressmannia

The first photometric observations of this object were done by Di Martino et al. in 1984. The lightcurves were found to have a period of 4.464 h. Denchev et al. (2000) observed 800 Kressmannia on five nights in 1997 and obtained a shorter period of 4.457 h.

We observed this asteroid on 22 nights during six apparitions in 2004, 2007, 2008, 2009, 2010, and 2012 in Borowiec, Pic du Midi, Rozhen, and Kielce observatories. Composite lightcurves from the first four apparitions (Figs. A.49–A.52) were obtained with a synodic period of 4.4610 ± 0.0003 h. Observations from 2010 (Fig. A.53) cover almost a five-month

[9] http://obswww.unige.ch/~behrend/r000428a.png
[10] http://obswww.unige.ch/~behrend/r000453a.png and r000453e.png
[11] http://obswww.unige.ch/~behrend/r000540a.png and r000540e.png
[12] http://obswww.unige.ch/~behrend/r000700a.png
[13] http://obswww.unige.ch/~behrend/r000770a.png and r00770e.png

time span. The best-fit period of 4.4615 ± 0.0001 h is slightly different. This value does not fit our observations from other apparitions and vice versa, and it is caused by the different observing geometry. Unfortunately, the lightcurve from 2012 (Fig. A.54) does not cover the whole cycle of rotation.

A.15. 802 Epyaxa

This object was observed by Bennefeld et al. (2009) on three consecutive nights in Dec. 2008 and by Warner (2009a) on two consecutive nights in Jan. 2009. The synodic periods obtained by them are 4.389 h and 4.392 h, respectively.

We observed Epyaxa on five nights during three apparitions in 2006 (Fig. A.55), 2009 (Fig. A.56), and 2010 (Fig. A.57) in Borowiec, Pic du Midi, and SAAO. The period of 4.392 ± 0.002 h derived by us confirms the result obtained by Bennefeld et al. (2009).

A.16. 825 Tanina

The first photometric observations of this object were carried out by Wisniewski on two nights in 1992 (Wisniewski et al. 1997). The derived period of 6.75 h was incorrect because of the half-cycle ambiguity between the lightcurves.

We observed this object during seven apparitions at both Borowiec and Pic du Midi in 1999, 2002, 2004/2005, 2006, 2007, 2009, and 2010 and obtained the 23 new lightcurves presented in Figs. A.58–A.64. The synodic period of 6.9398 ± 0.0001 h fits perfectly to all of our data as well as Wisniewski et al.

A.17. 827 Wolfiana

The first lightcurve of Wolfiana was observed during one night in Nov. 2009 at Pic du Midi. We covered more than one rotational cycle and estimated the synodic period to be 4.0 ± 0.1 h (Fig. A.65).

A.18. 841 Arabella

Binzel & Mulholland (1983) observed Arabella on two nights in 1982 and despite very sparse lightcurves obtained a period of 3.39 h.

We observed Arabella on three nights in 2004 and 2007 at Kharkov and Borowiec. We fitted the synodic period of 3.352 ± 0.005 h to our lightcurves (Figs. A.66, A.67), which is close to the Binzel & Mulholland determination.

A.19. 864 Aase

The first lightcurve of this object was observed by ourselves at Pic du Midi in December 2007 (Fig. A.68). We continued photometric observations of this object at different observing geometries in 2009 (Fig. A.69) and 2010/2011 (Fig. A.70) oppositions. All seven lightcurves with amplitudes of 0.35–0.4 mag can be perfectly fit with the synodic period of 3.2325 ± 0.0001 h.

A.20. 905 Universitas

Tedesco (1979) and Wisniewski et al. (1997) observed Universitas on single nights in 1977 and 1992. They both estimated a period of 10 h. Fauerbach et al. (2008) observed it on four nights in Nov. 2007 and obtained a period of 14.157 h. Stephens (2008) observed Universitas on five nights in Oct. 2007 and obtained a period of 14.238 h. Lightcurve from two nights in Apr. 2009[14] was composited with the period of 14.24 h.

Our four lightcurves obtained at Borowiec in 2004 are folded with the best-fit period of 14.238 ± 0.003 h (Fig. A.71), which confirms Stephens determination.

A.21. 913 Otilla

Schiller & Lacy (2008) observed this object on four nights in June and July 2007. The period of 4.8024 h was obtained from rather noisy lightcurves. Oey & Krajewski (2008) observed Otila on five nights in April and May 2007. They derived a period of 4.8720 h from the 0.2 mag amplitude lightcurve.

We observed 913 Otila on six nights in March and April 2010. Our lightcurve of 0.1 mag amplitude shown in Fig. A.72 was obtained with a synodic period of 4.8719 ± 0.0001 h, which confirms the determination of Oey and Krajewski.

A.22. 915 Cosette

Di Martino et al. (1994b) first observed the lightcurves of this object in 1984 and determined a period of 4.445 h. The composite lightcurve from 2004 reported by Behrend[15] was plotted with a period of 4.4529 h.

We observed 915 Cosette during five apparitions in 2004, 2006, 2008/2009, 2010, and 2011/2012 at the Borowiec and Pic du Midi observatories and obtained 14 new dense and high-quality lightcurves of amplitudes from 0.4 mag to 0.8 mag presented in Figs. A.73–A.77. The period fitted to the whole dataset is 4.4702 ± 0.0001 h, which is unambiguous determination based on data spreaded over a six-month span in the last apparition. Previous values of the synodic period do not at all fit our dataset.

A.23. 937 Bethgea

Di Martino et al. (1994a) observed Bethgea on five consecutive nights in September 1990 and got a synodic period of 8.356 ± 0.006 h.

We obtained 16 lightcurves of this object during five apparitions at different observing geometries in 2000 (Fig. A.78), 2004 (Fig. A.79), 2007 (Fig. A.80), 2009 (Fig. A.81), 2010 (Fig. A.82), and 2012 (Fig. A.83) at the Borowiec, Pic du Midi, Rozhen and Kielce observatories. The synodic period of 7.538 ± 0.001 h fitted to our dataset is almost one hour shorter than the one obtained by Di Martino et al. The Bethgea lightcurves are rather irregular with additional humps that strengthen the period determination. The only set of regular lightcurves was obtained in 2004, which have a geometry similar to the 1990 data. The period of 8.356 h does not fit at all to our dataset. The period of 7.539 h fits to the first three lightcurves of Di Martino et al. and suggests that there is an error in time in the files available in the Uppsala Asteroid Photometric Catalog Ver.5 files.

[14] http://obswww.unige.ch/~behrend/r000905a.png
[15] http://obswww.unige.ch/~behrend/r000915a.png

A.24. 960 Birgit

The lightcurve of Birgit from the 2005 apparition[16] which was found to have a period of 17.3558 h, has a very strange shape, and seems to be wrongly folded because of some erroneous data.

We observed Birgit on three consecutive nights in Feb. 2007 at Pic du Midi and determined a synodic period of 8.85 ± 0.05 h for this object (Fig. A.84). This value is close to half of the former determination.

A.25. 967 Helionape

Helionape was observed photometrically for the first time within this campaign in 2007 and 2009 in Rozhen, Borowiec, and Pic du Midi. Two lightcurves from Rozhen and a first period determination of 3.234 ± 0.002 h were published by Apostolovska et al. (2009). A composite lightcurve from the 2007 apparition (Fig. A.85) has an extremely low amplitude of 0.05 mag and with help of additional lightcurve from Borowiec was folded with the period of 3.232 ± 0.002 h. The lightcurve obtained for the 2009 oppostion from Pic du Midi is shown in Fig. A.86.

A.26. 1016 Anitra

Menke (2005) observed Anitra on eight nights during the 2002/2003 apparition and determined a period of 5.9300 h. Pray et al. (2006) observed Anitra on 5 nights in Oct. 2005 and obtained a period of 5.928 h.

We observed Anitra on six nights in Borowiec in Sep. and Oct. 2005. The best fit to the composite lightcurve was obtained for a synodic period of 5.9288 ± 0.0007 h. Our composite lightcurve presented in Fig. A.87 is of a slightly different shape than the one presented by Pray et al. despite very similar observing geometry.

A.27. 1055 Tynka

Higgins & Pilcher (2009) observed Tynka on six nights from April to June 2009 and obtained a period of 11.893 h.

We observed Tynka during the same opposition on six nights in Apr. and May 2009 at Borowiec. Unfortunately, a shortening of the observing window at the Borowiec latitude did not allow us to continue observations. A period of rotation close to 12 h meant that we covered almost the same part of the lightcurve each night. Our composite lightcurve presented in Fig. A.88 confirms the Higgins & Pilcher period determination.

A.28. 1056 Azalea

The rather noisy lightcurve of Azalea from three consecutive nights in Feb. 2004 reported by Behrend[17], was obtained with the period of 15.15 h.

We observed Azalea on 13 nights during three oppositions in 2004, 2008, and 2011 at both Borowiec and Pic du Midi. Our lightcurves of amplitudes ranging from 0.7 mag to 0.3 mag presented in Figs. A.89–A.91 were obtained with the synodic period of 15.03 ± 0.01 h. The period of 15.15 h does not fit our dataset.

[16] http://obswww.unige.ch/~behrend/r000960a.png
[17] http://obswww.unige.ch/~behrend/r001056a.png

A.29. 1060 Magnolia

Magnolia was observed by Wisniewski et al. (1997) on a single night in 1992. The period of rotation was estimated to 2.78 h. Two lightcurvves from 2009[18] are folded with the period of 2.9107 h.

Our 15 lightcurves were obtained during six apparitions in 2002, 2005, 2006, 2008, 2009, and 2011 at Pic du Midi, Rozhen, and Kharkov. The lightcurve amplitudes varied from 0.07 mag in 2011 to 0.25 mag in 2002. Our value of synodic period of 2.9108 ± 0.0003 h is based on the lightcurves spread over more than a three-month time span in 2008. Composite lightcurves are presented in Figs. A.92–A.97.

A.30. 1088 Mitaka

The first photometric observations of Mitaka covering almost two rotation cycles were performed by Wisniewski et al. (1997) on one night in Nov. 1989. They determined a period of 3.049 h. Two lightcurves of Mitaka from 2004 and 2010[19] have periods of 3.0354 h and 3.0361 h, respectively.

We observed Mitaka during seven apparitions in 2002, 2004, 2005, 2006/2007, 2008, 2009/2010, and 2011 at Borowiec, Pic du Midi, Kharkov, Kielce, Rozhen, SAAO, and Pico dos Dias, and obtained 19 lightcurves of different amplitudes from 0.6 mag in 2002 to 0.3 mag in 2008 and 2009/2010 (see Figs. A.99–A.104). The value of the synodic period of 3.0353 ± 0.0001 h is based on lightcurves spread on almost four-month time span in both the 2006/2007 and 2009/2010 apparitions.

A.31. 1117 Reginita

Wisniewski et al. (1997) observed Reginita on two nights in 1988, obtaining a period of 2.9463 h. The lightcurve of Reginita from 2007[20], was created with the period of 2.9458 h.

We observed Reginita on 19 nights during six apparitions in 2002, 2004, 2005, 2006/2007, 2009/2010, and 2011 at Pic du Midi, Borowiec, Kharkov, and Rozhen. The period of 2.9464 ± 0.0001 fitted to our dataset is based on data covering a long time-span between lightcurves in both the 2009/2010 and 2011 apparitions, and confirms the Wisniewski at al. determination. Composite lightcurves are presented in Figs. A.105–A.111.

A.32. 1130 Skuld

The lightcurve of Skuld from three nights in 2002[21] has a best-fit period of 4.810 h. Buchheim (2010) observed Skuld during its 2009 apparition and obtained a period of 4.807 h.

We observed this object on 14 nights during five apparitions in 2004, 2006/2007, 2008, 2009, and 2011 at Borowiec, Pic du Midim, and Rozhen. Our lightcurves (Figs. A.112–A.116) have the synodic period of 4.8079 ± 0.0003 h, confirming former period determinations.

[18] http://obswww.unige.ch/~behrend/r001060a.png
[19] http://obswww.unige.ch/~behrend/r001088e.png and r001088a.png
[20] http://obswww.unige.ch/~behrend/r001117a.png
[21] http://btboar.tripod.com/lightcurves/id34.html

A.33. 1133 Lugduna

We observed this object on eight nights in two apparitions in 2009 and 2010 at Borowiec and obtained the 0.4 mag and 0.45 mag amplitude lightcurves presented in Figs. A.117–A.118. The lightcurves of 2009 were obtained with the Borowiec PST telescope. On the night 12/13 May 2009, observations were carried out simultaneously using both mirrors of this telescope (PST and PST2). The synodic period derived from our data is 5.478 ± 0.002 h.

A.34. 1188 Gothlandia

This asteroid was observed by Di Martino et al. (1994b) on two consecutive nights in Sep. 1985. They obtained a period of 3.493 h from their symmetric lightcurves. Lightcurves of Gothlandia from 2006 and 2007[22] are folded with the periods of 3.4920 h and 3.4921 h. Hamanowa & Hamanowa (2009) observed Gothlandia during the 2009/2010 apparition and obtained a period of 3.4915 h.

We observed this asteroid on 14 nights during four apparitions in 2006, 2008/2009, 2010, and 2011/2012 in Borowiec and SAAO. All lightcurves presented in Figs. A.119–A.122 have large amlitudes of 0.6–0.8 mag and are folded with a period of 3.4917 ± 0.0001 h. For the last apparition, we found a slightly different period of 3.4915 ± 0.0001 h.

A.35. 1219 Britta

Britta was identified as a potential flyby target for the Galileo spacecraft and became a focus of an observing program reported by Binzel et al. (1987). Additional lightcurves were obtained by Pilcher et al. (1985). They reported a synodic period of rotation of 5.5752 h and large amplitudes of 0.6–0.7 mag.

We observed Britta during six apparitions in 2003, 2005, 2006, 2008, 2009, and 2010/2011 at Borowiec, Pic, du Midi, SAAO, San Pedro de Atacama, and Rozhen. All of the 18 observed lightcurves have large amplitudes of 0.5–0.7 mag despite variations in the viewing geometry which suggest that the spin vector is perpendicular to the ecliptic plane. Our value of the synodic period is 5.5752 ± 0.0002 h for the 2008 apparition and 5.5748 ± 0.0002 h for 2010/2011 apparition. Composite lightcurves for other oppositions were created with the average value of the period of 5.5750 h because there were insufficient dataset to distinguish between two determined values. Composite lightcurves are presented in Figs. A.123–A.128.

A.36. 1249 Rutherfordia

Lightcurves of Rutherfordia from four nights in Aug. 2001 and two nights in Jul. 2004[23] have periods of 18.20 and 18.24 h, respectively.

Our four incomplete and high-amplitude (0.6 mag) lightcurves were obtained in 2005 and 2008 in Borowiec. Despite the incompleteness of the lightcurves, we were able to strengthen the solution of the synodic period, because we perfectly covered the same maximum twice, over a time interval of about two weeks. Lightcurves presented in Figs. A.129, A.130 are folded with the period of 18.220 ± 0.005 h.

[22] http://obswww.unige.ch/~behrend/r001188e.png and r001188i.png

[23] http://obswww.unige.ch/~behrend/r001249e.png and r001249a.png

A.37. 1376 Michelle

The first lightcurve of Michelle was gathered by Wisniewski et al. (1997) in 1988. A period of 6.0 h was estimated for this object. Hamanowa & Hamanova (2009) observed Michelle on five nights in Oct. 2008 and obtained a period of 5.9748 h. Its lightcurve[24] consists of Hamanowa & Hamanowa data plus one aditional lightcurve and is folded with a period of 5.9766 h.

Our eight lightcurves of Michelle were obtained during four apparitions in 2004, 2005, 2007, and 2008 at Kharkov, Pic du Midi, and Borowiec. The value of synodic period of 5.9769 ± 0.0005 h is consitent with the Behrend determination. Composites are presented in Figs. A.131–A.134.

A.38. 1523 Pieksamaki

Lagerkvist (1979) observed Pieksamaki using photographic photometry on two nights in 1977 and obtained a period of 5.33 h. Pray et al. (2006) observed Pieksamaki on five nights in Dec. 2005 and got synodic period of 5.3202 h.

Our eight lightcurves of Pieksamaki were gathered at Borowiec, Pic du Midi, Rozhen, and SAAO during its 2004, 2006, 2007, 2008, and 2010 apparitions and confirm the aforementioned 5.3202 h period. Lightcurves are presented in Figs. A.135–A.139.

A.39. 1562 Gondolatsch

Gondolatsch was observed by Lagerkvist (1979) on two nights in Aug. 1977. The period of 8.6 h was derived from a rather noisy photographic lightcurve. Composite lightcurves from 2003 and 2006[25] were created with the periods of 8.78 h and 8.71 h. They were obtained using data acquired over two consecutive nights in both cases.

We observed Gondolatsch on three nights in 2006 at Borowiec. Fot the best-fit composite lightcurve (Fig. A.140), we derived the period of 8.74 ± 0.01 h, which is an average of the last two determinations.

A.40. 1590 Tsiolkovskaya

Tsiolkovskaja was observed by Lagerkvist (1978) on one night in 1976 and the period of 6.7 h was estimated from the resulting photographic lightcurve. Warner (2008) observed this object on three consecutive nights in Nov. 2007 and obtained a period of 6.737 h. Carbo et al. (2009) observed Tsiolkovskaja on five nights in Mar. 2008, obtaining a period of 6.731 h.

We observed Tsiolkovskaja on four nights in Dec. 2007 and Feb. 2008 at Pic du Midi. The period obtained from our lightcurves is 6.7299 ± 0.0003 h (Fig. A.141). The Carbo period doed not fit our dataset, but Warner's data which are available at IAU MPC webpage, folded with our period provides a very good-quality composite lightcurve. Unfortunately an incomplete additional lightcurve was obtained in 2010 at Borowiec (Fig. A.142).

[24] http://obswww.unige.ch/~behrend/r001376a.png

[25] http://obswww.unige.ch/~behrend/r001562e.png and r001562a.png

A.41. 1601 Patry

Lightcurves of this asteroid from three nights in May 2002[26], were fitted with a period of 5.92 h. Because we observed Patry during only one night in June 2009, we adopted the above-mentioned period (Fig. A.143).

A.42. 1619 Ueta

This object was observed on a single night in 2000 by Almeida et al. (2004). Despite the sparse lightcurve, they determined a period of rotation of 2.94 h.

We observed Ueta on six nights during apparitions in 2009 (Fig. A.144) and 2010 (Fig. A.145) at both Borowiec and Rozhen. Our synodic period of 2.7180 ± 0.0002 h is shorter than the one previously determined by Almeida et al. and is based on more than 350 rotations of the object between the most distant lightcurves.

A.43. 1667 Pels

The only photometric observations of this object were done by Wisniewski et al. (1997) on two consecutive nights in April 1991. The period determined for Pels was 3.268 h.

We observed Pels on 12 nights during six apparitions in 2004, 2005, 2007, 2008/2009, 2010, and 2011 in Borowiec, Pic du Midi, SAAO, and NOT La Palma. The synodic period of 3.2681 ± 0.0001 h determined from our lightcurves confirms Wisniewski value. Composites are presented in Figs. A.146–A.151. A large difference among the amplitudes of the lightcurves from 2008/2009 (Fig. A.149) is caused by an almost 20 deg difference in the phase angle.

A.44. 1675 Simonida

Wisniewski et al. (1997) observed this object on a single night in 1988, and estimated a period of 5.3 h.

We observed Simonida during five apparitions in 2004, 2005, 2008, 2009, and 2010/2011 in Borowiec, Pic du Midi, San Pedro de Atacama, Rozhen, and SAAO, and obtained 18 lightcurves of different amplitudes from 0.3 mag to 0.7 mag. The period of 5.2885 ± 0.0002 fits the whole dataset. Composite lightcurves are presented in Figs. A.152–A.156.

A.45. 1682 Karel

First photometric observations of Karel were done by us in Jan 2008 at Pic du Midi. Because we suspected that this object could be a binary system, observations covered several rotation cycles. Unfortunately, our suspicion appeared to be based on an artefact in one lightcurve. The subsequent observations allowed for a more precise period determination, which is 3.3750 ± 0.0001 h. The composite lightcurve from 2008 is presented in Fig. A.157. Lightcurve from 2009 from San Pedro de Atacama is shown in Fig. A.158 and that of 2010 from Pic du Midi in Fig. A.159.

A.46. 1793 Zoya

This object was observed by Lagerkvist (1978) on one night in 1973. The period of about 7 h was estimated from photographic photometry. Brinsfield (2008) observed Zoya on four nights in 2008 and obtained a period of 5.753 h from a 0.4 mag amplitude lightcurve.

Our lightcurves of the high-amplitude of 0.7 mag, from two consecutive nights observed at the Borowiec observatory presented in Fig. A.160 were obtained at extremely low temperatures for this observatory, lower than –20 deg C. The period of 5.74 ± 0.01 h confirms the Brinsfield determination.

A.47. 2017 Wesson

Wisniewski (1997) observed Wesson on three nights in May 1987 and determined a period of 2.988 h.

We observed this object on 17 nights during apparitions in 2004, 2005/2006, 2007, 2008/2009, 2010, and 2011 at Pic du Midi, Rozhen, Borowiec, and SAAO. The synodic period of 3.4158 ± 0.0002 calculated by us is based on a three month span between our lightcurves in 2009 and fits to all apparitions except those in 2011. For a 2011 apparition, we obtained a slightly different period of 3.4156 h $\pm$ 0.0002 h, which is also based on 3 month span between the lightcurves. Composites are presented in Figs. A.161–A.166. The obtained period is almost half an hour longer than the Wisniewski's determination and also perfectly fits to Wisniewski data, resolving the the full-cycle ambiguity between his lightcurves.

A.48. 2036 Sheragul

Sheragul was observed on five nights in 2003 by Clark (2004) and the period of 5.41 h was obtained from that data.

We obseved Sheragul on only one night in 2007 at Pic du Midi. Our lightcurve is folded with the period of 5.45 ± 0.05 h (Fig. A.167).

A.49. 2156 Kate

Binzel and Mulholland (1983) observed Kate on four consecutive nights in November 1981 and got a large amplitude (0.6 mag) composite lightcurve of the period 5.62 h.

We observed Kate on 17 nights during six oppositions in 2001, 2003, 2006, 2008/2009, 2010 and 2011 (Figs. A.168–A.173 at Borowiec, Pic du Midi, Rozhen, and SAAO. Our lightcurves of large amplitudes from 0.65 mag to 1 mag in 2006 were composed with the period of 5.623 ± 0.002 h. Sharp minima in the lightcurve from 2006 suggest contact-binary shape of this object.

A.50. 2283 Bunke

Bunke was observed by Menke (2005) on three nights in 2003. The lightcurve of the period 3.96 h is very noisy and of very low amplitude (0.06 mag).

We observed this object only on 2 nights in 2004 (Fig. A.174) at Kharkov, and in 2009 (Fig. A.175) at Pic du Midi. Dense low-noise lightcurve of 0.06 mag amplitude from 2009 covers the whole rotation period, which we estimated to be 4.3 ± 0.1 h. This value is close to the next most-likely alias period of about 4.20 h derived by Menke.

[26] http://obswww.unige.ch/~behrend/r001601d.png

A.51. 2460 Mitlincoln

Warner (2002) observed Mitlincoln on two nights in 2002 and obtained a period of 2.770 h. Lightcurves from 2004[27] have a best-fit period of 3.009 h.

We observed Mitlincoln on ten nights in 2004, 2007 and 2009 at Rozhen, Pic du Midi, Kharkov, and Borowiec. The synodic period of 2.8277 ± 0.0001 obtained by us is based on almost three month span among the observed lightcurves in 2009 apparition. Former values do not fit to our dataset at all. Composite lightcurves are presented in Figs. A.176–A.178.

A.52. 2961 Katsurahama

Warner (2000) observed Katsurahama on two nights in Nov. 1999 and obtained a period of 2.935 h. Recent analysis of the same dataset (Warner 2010) gave a slightly longer period of 2.936 h.

Our observations of Katsurahama were done on four nights during the 2006, 2008, and 2009 apparitions at Rozhen and Borowiec. The period obtained by us of 2.937 ± 0.004 h is consistent with Warner's determination. Composite lightcurves are presented in Figs. A.179–A.181.

A.53. 3953 Perth

Wisniewski et al. (1997) observed Perth on a single night in Dec. 1993 and estimated a period of 5.2 h.

We observed Perth on four nights during three apparitions in 2008, 2010, and 2011 at Rozhen and Pic du Midi. Unfortunately, the lightcurve from 2011 covers only half of the rotation cycle. We obtained the best-fit to the composite lightcurve for the synodic period of 5.083 ± 0.009 h. Our results are presented in Figs. A.182–A.184.

A.54. 3986 Rozhkovskij

This object was observed on two nights in 1995 by Birlan et al. (1996) and a period of 4.26 h was determined. The lightcurves of Rozhkovskij obtained by Warner on two nights in 2010[28] have the period of 3.548 h.

Each of our lightcurves of this object from two nights in Aug. 2005 and Sep. 2005 gathered at Rozhen (Fig. A.185) covers almost two cycles of rotation. The period of 3.5493 ± 0.0002 h fits to our and Warner's data.

A.55. 4150 Starr

The poorly covered lightcurve of this object was folded with the period of 6.8 h by Angeli et al. (2001).

We observed Starr on five nights during two apparitions in 2004 and 2011 at Rozhen, Borowiec, and NOT La Palma. The lightcurve from 2004 (Fig. A.186) has a very low amplitude of 0.09 mag and shows only one minimum and maximum per cycle of rotation. The lightcurve from 2011 (Fig. A.187) has a classical double peak shape. The synodic period of rotation of Starr is 4.5179 ± 0.0005 h.

A.56. Negative period determinations

Four objects observed by us, 341 California, 525 Adelaide, 763 Cupido, and 1123 Shapleya, have long periods of rotation (longer than 40 h, 20 h, 24 h and 24 h respectively). Unfortunately, our dataset was insufficient to obtain a solution for their synodic periods. These objects however constitute less than 7% of our sample and have little influence on the final result.

[27] `http://obswww.unige.ch/~behrend/r002460a.png`

[28] `http://www.minorplanetobserver.com/pdolc/A3986_2010.HTM`

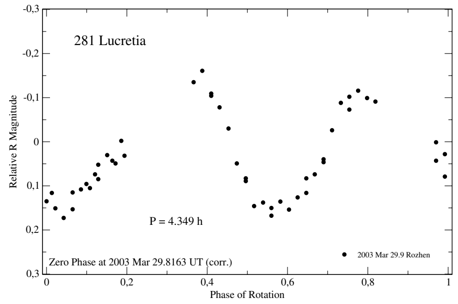

Fig. A.1. Composite lightcurve of 281 Lucretia from its 2003 opposition.

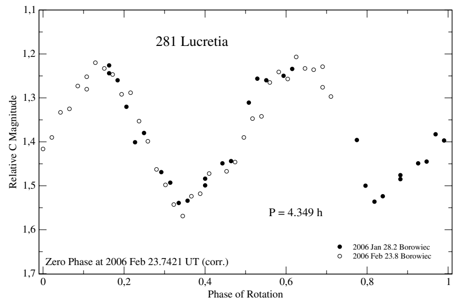

Fig. A.2. Composite lightcurve of 281 Lucretia from its 2006 opposition.

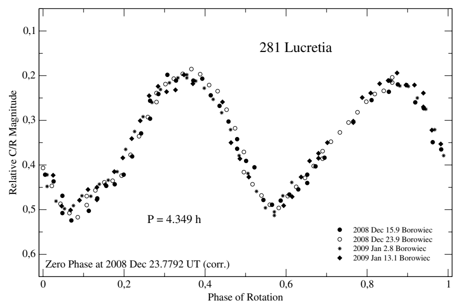

Fig. A.3. Composite lightcurve of 281 Lucretia from its 2008/2009 opposition.

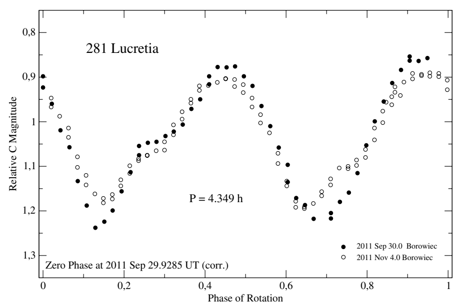

Fig. A.4. Composite lightcurve of 281 Lucretia from its 2011 opposition.

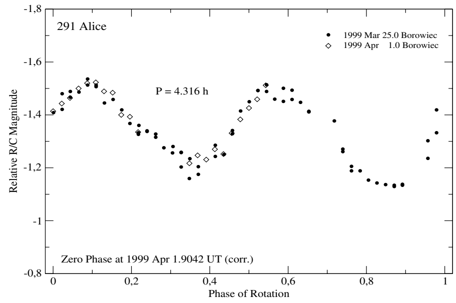

Fig. A.5. Composite lightcurve of 291 Alice from its 1999 opposition.

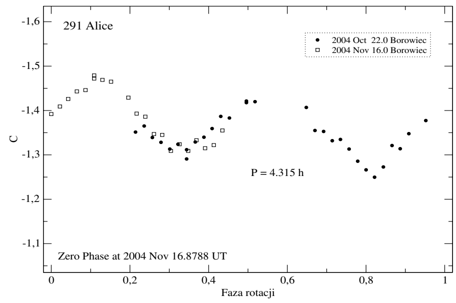

Fig. A.6. Composite lightcurve of 291 Alice from its 2004 opposition.

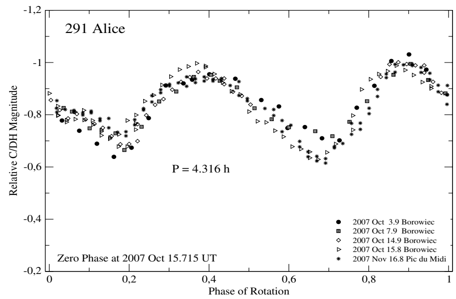

Fig. A.7. Composite lightcurve of 291 Alice from its 2007 opposition.

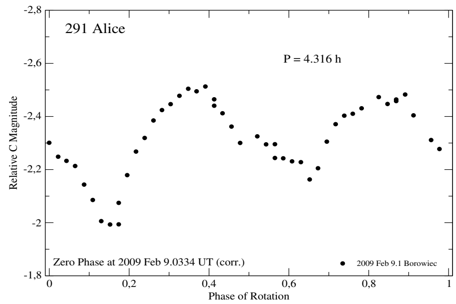

Fig. A.8. Composite lightcurve of 291 Alice from its 2009 opposition.

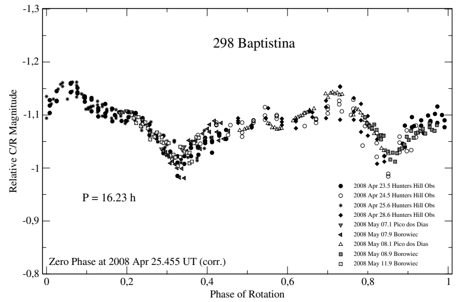

Fig. A.9. Composite lightcurve of 298 Baptistina from its 2008 opposition.

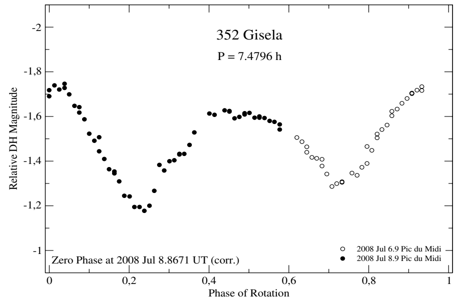

Fig. A.13. Composite lightcurve of 352 Gisela from its 2008 opposition.

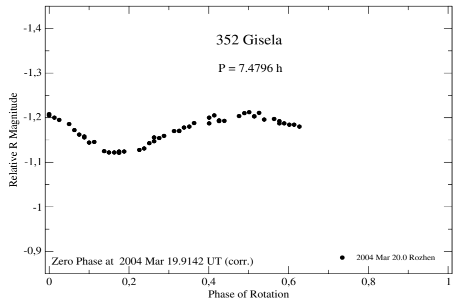

Fig. A.10. Composite lightcurve of 352 Gisela from its 2004 opposition.

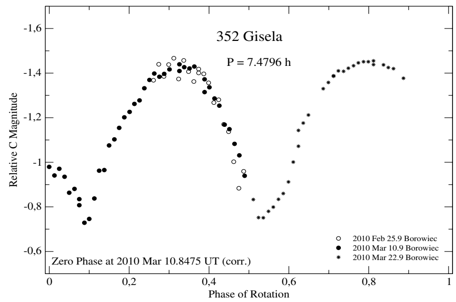

Fig. A.14. Composite lightcurve of 352 Gisela from its 2010 opposition.

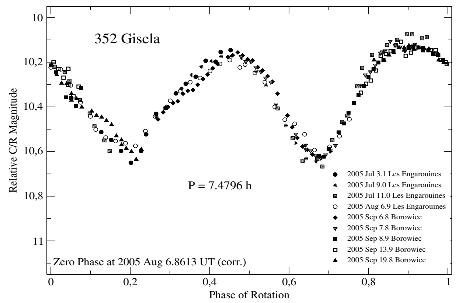

Fig. A.11. Composite lightcurve of 352 Gisela from its 2005 opposition.

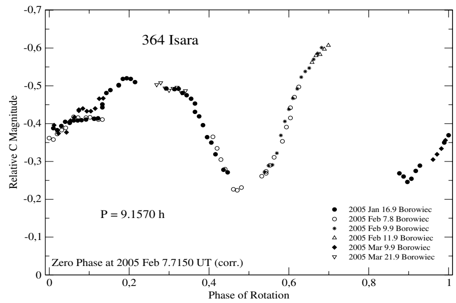

Fig. A.15. Composite lightcurve of 364 Isara from its 2005 opposition.

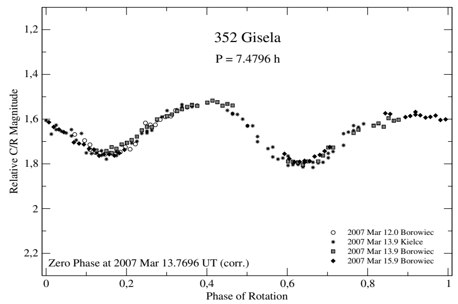

Fig. A.12. Composite lightcurve of 352 Gisela from its 2007 opposition.

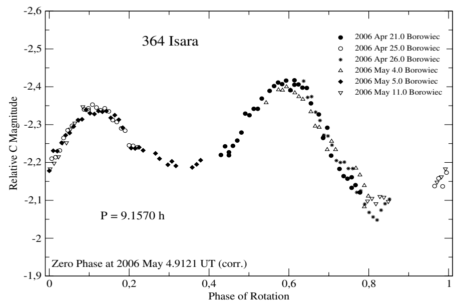

Fig. A.16. Composite lightcurve of 364 Isara from its 2006 opposition.

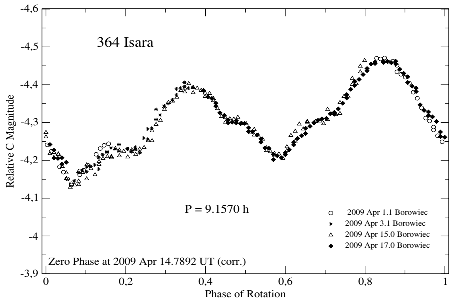

Fig. A.17. Composite lightcurve of 364 Isara from its 2009 opposition.

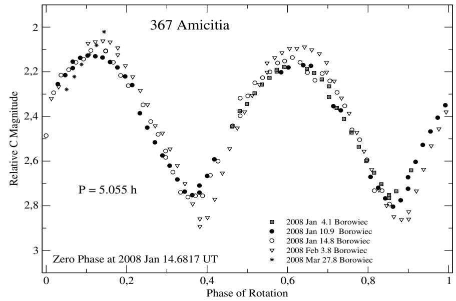

Fig. A.21. Composite lightcurve of 367 Amicitia from its 2008 opposition.

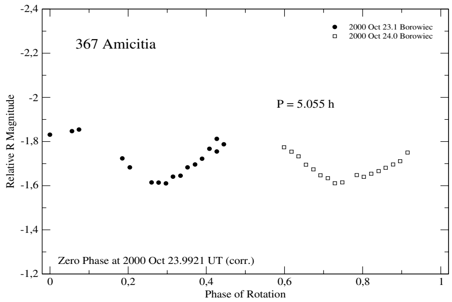

Fig. A.18. Composite lightcurve of 367 Amicitia from its 2000 opposition.

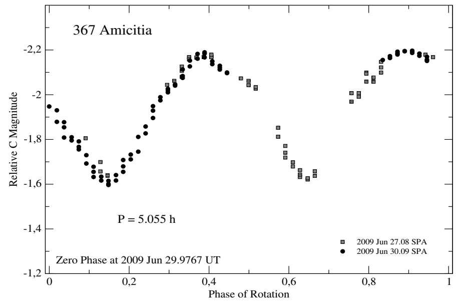

Fig. A.22. Composite lightcurve of 367 Amicitia from its 2009 opposition.

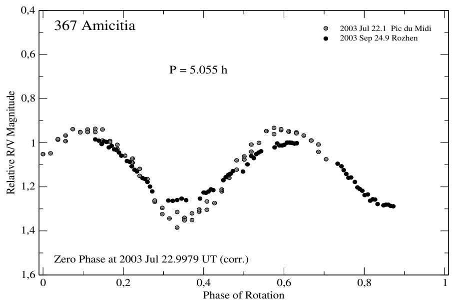

Fig. A.19. Composite lightcurve of 367 Amicitia from its 2003 opposition.

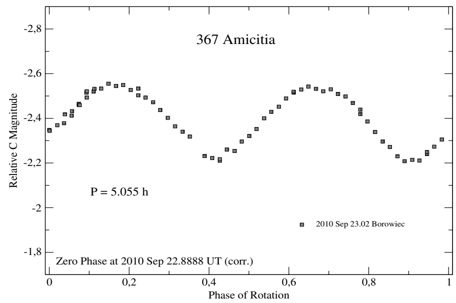

Fig. A.23. Composite lightcurve of 367 Amicitia from its 2010 opposition.

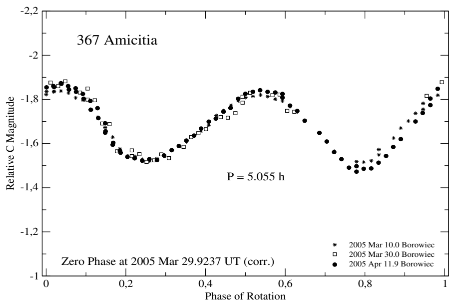

Fig. A.20. Composite lightcurve of 367 Amicitia from its 2005 opposition.

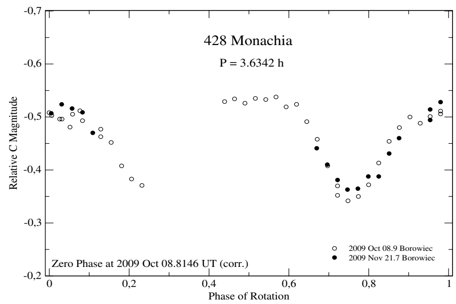

Fig. A.24. Composite lightcurve of 428 Monachia from its 2009 opposition.

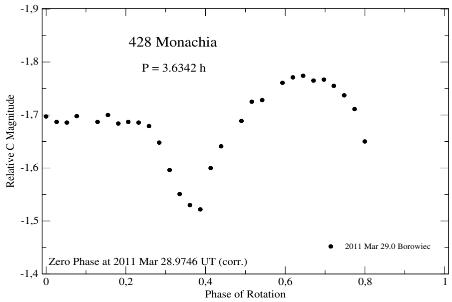

Fig. A.25. Composite lightcurve of 428 Monachia from its 2011 opposition.

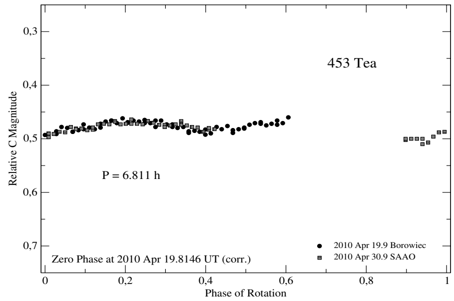

Fig. A.29. Composite lightcurve of 453 Tea from its 2010 opposition.

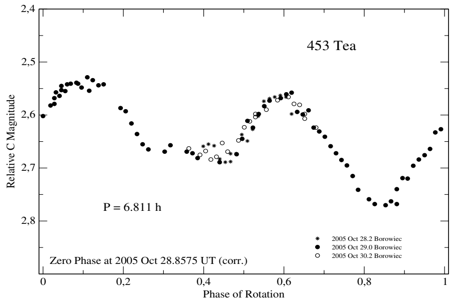

Fig. A.26. Composite lightcurve of 453 Tea from its 2005 opposition.

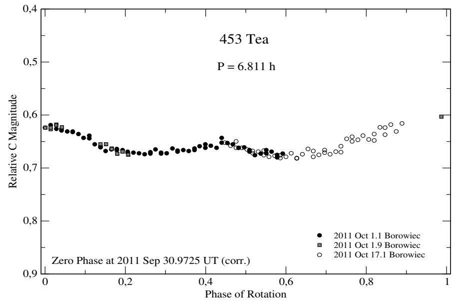

Fig. A.30. Composite lightcurve of 453 Tea from its 2011 opposition.

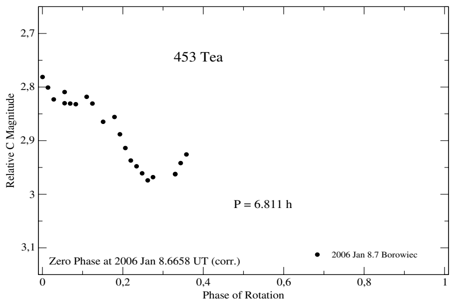

Fig. A.27. Composite lightcurve of 453 Tea from its 2006 opposition.

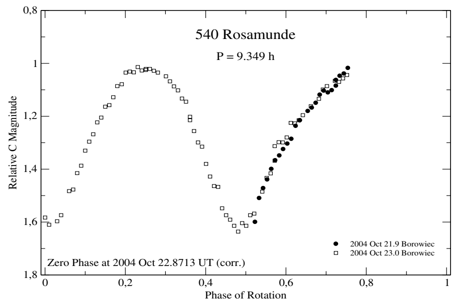

Fig. A.31. Composite lightcurve of 540 Rosamunde from its 2004 opposition.

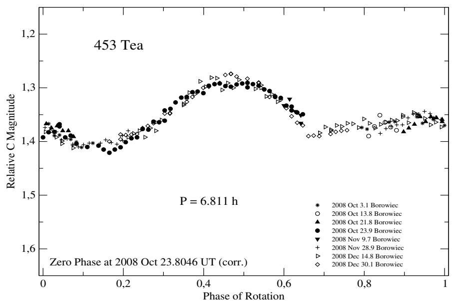

Fig. A.28. Composite lightcurve of 453 Tea from its 2008 opposition.

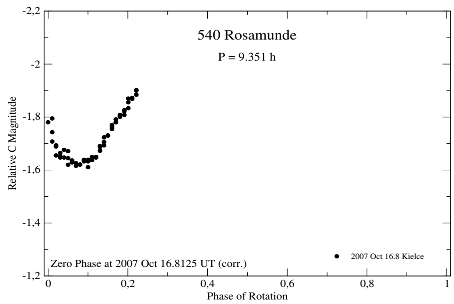

Fig. A.32. Composite lightcurve of 540 Rosamunde from its 2007 opposition.

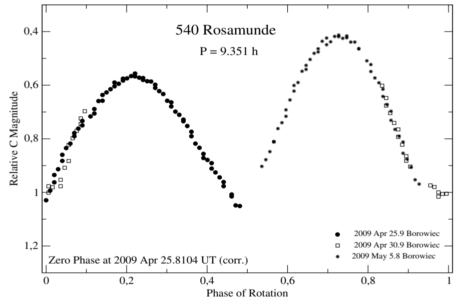

Fig. A.33. Composite lightcurve of 540 Rosamunde from its 2009 opposition.

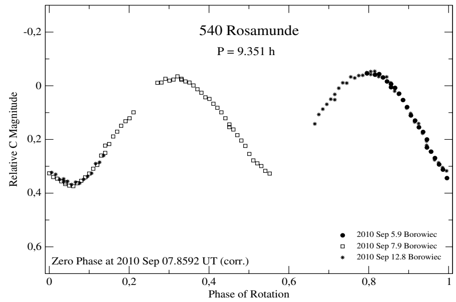

Fig. A.34. Composite lightcurve of 540 Rosamunde from its 2010 opposition.

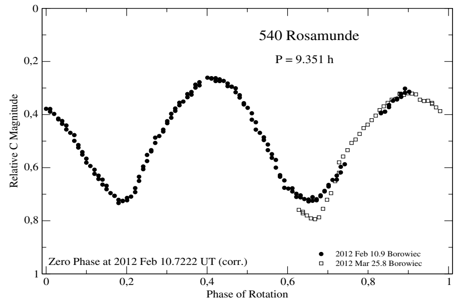

Fig. A.35. Composite lightcurve of 540 Rosamunde from its 2012 opposition.

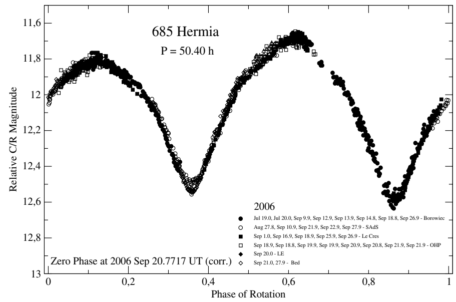

Fig. A.36. Composite lightcurve of 685 Hermia from its 2006 opposition.

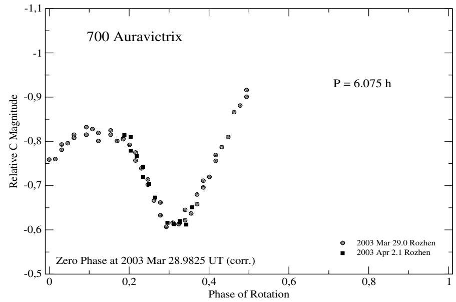

Fig. A.37. Composite lightcurve of 700 Auravictrix from its 2003 opposition.

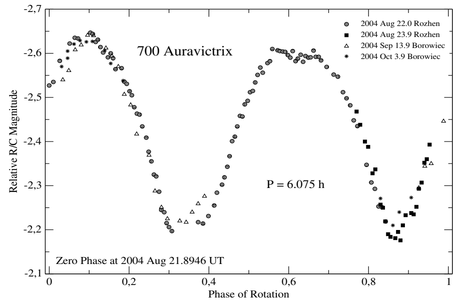

Fig. A.38. Composite lightcurve of 700 Auravictrix from its 2004 opposition.

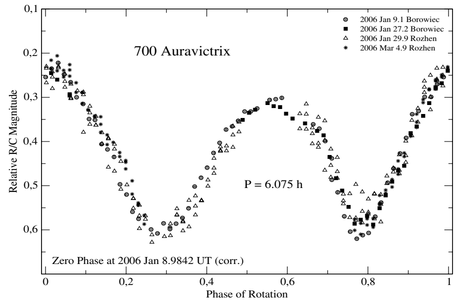

Fig. A.39. Composite lightcurve of 700 Auravictrix from its 2006 opposition.

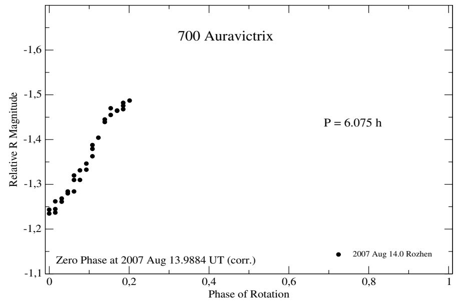

Fig. A.40. Composite lightcurve of 700 Auravictrix from its 2007 opposition.

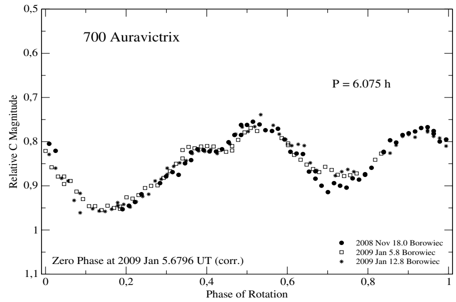

Fig. A.41. Composite lightcurve of 700 Auravictrix from its 2008/2009 opposition.

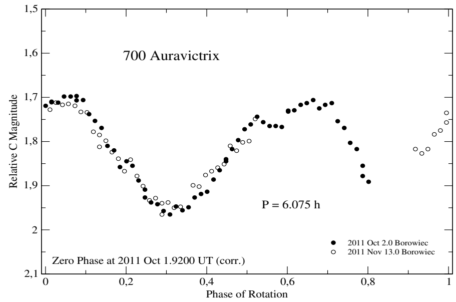

Fig. A.42. Composite lightcurve of 700 Auravictrix from its 2011 opposition.

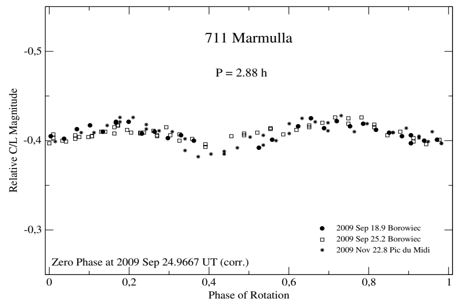

Fig. A.43. Composite lightcurve of 711 Marmulla from its 2009 opposition.

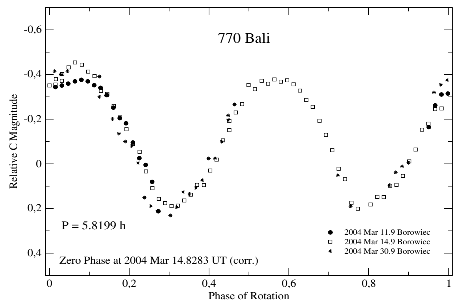

Fig. A.44. Composite lightcurve of 770 Bali from its 2004 opposition.

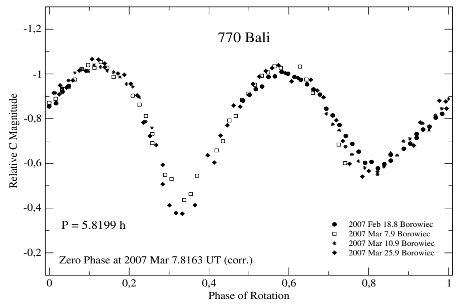

Fig. A.45. Composite lightcurve of 770 Bali from its 2007 opposition.

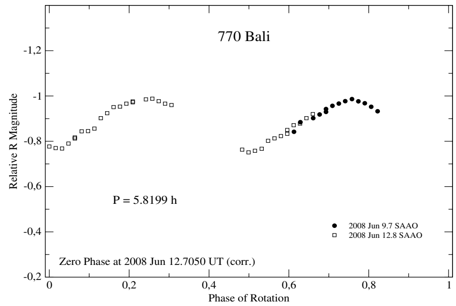

Fig. A.46. Composite lightcurve of 770 Bali from its 2008 opposition.

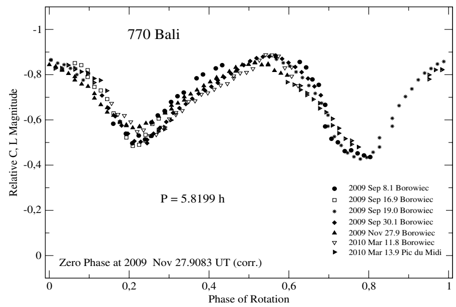

Fig. A.47. Composite lightcurve of 770 Bali from its 2009/2010 opposition.

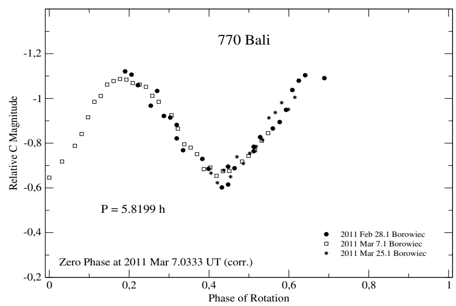

Fig. A.48. Composite lightcurve of 770 Bali from its 2011 opposition.

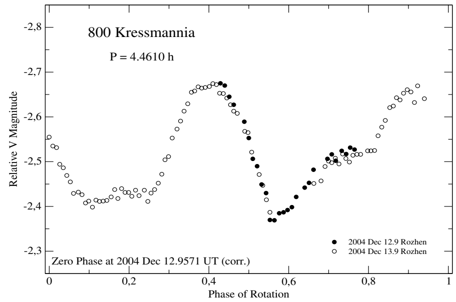

Fig. A.49. Composite lightcurve of 800 Kressmannia from its 2004 opposition.

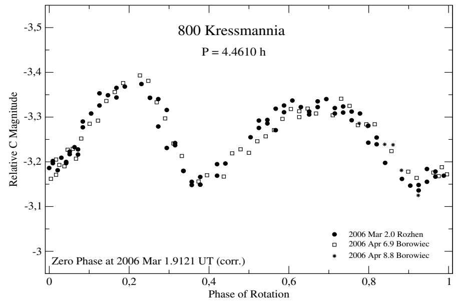

Fig. A.50. Composite lightcurve of 800 Kressmannia from its 2006 opposition.

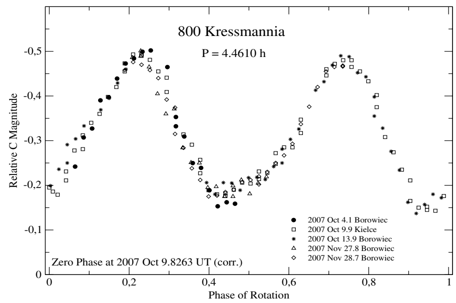

Fig. A.51. Composite lightcurve of 800 Kressmannia from its 2007 opposition.

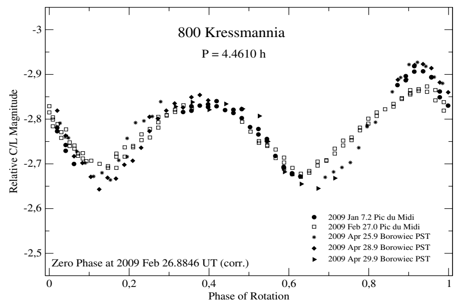

Fig. A.52. Composite lightcurve of 800 Kressmannia from its 2009 opposition.

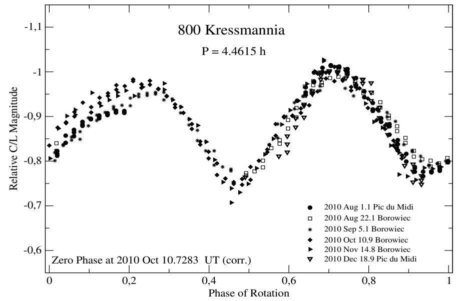

Fig. A.53. Composite lightcurve of 800 Kressmannia from its 2010 opposition.

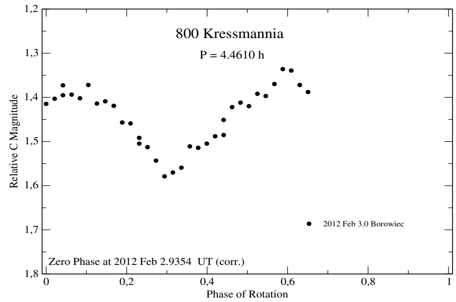

Fig. A.54. Composite lightcurve of 800 Kressmannia from its 2012 opposition.

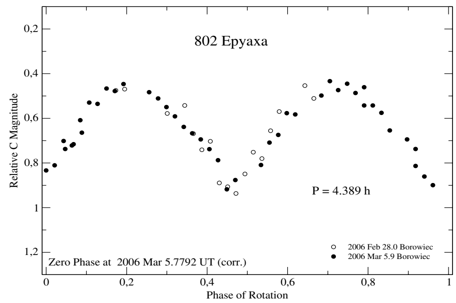

Fig. A.55. Composite lightcurve of 802 Epyaxa from its 2006 opposition.

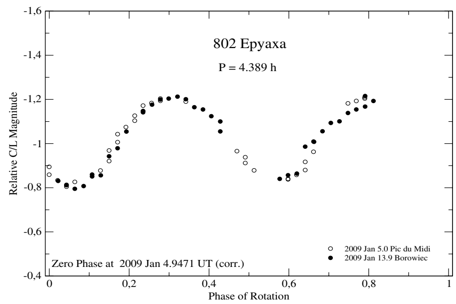

Fig. A.56. Composite lightcurve of 802 Epyaxa from its 2009 opposition.

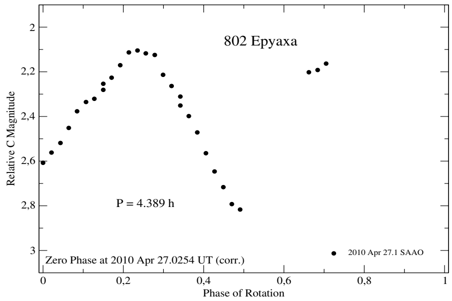

Fig. A.57. Composite lightcurve of 802 Epyaxa from its 2010 opposition.

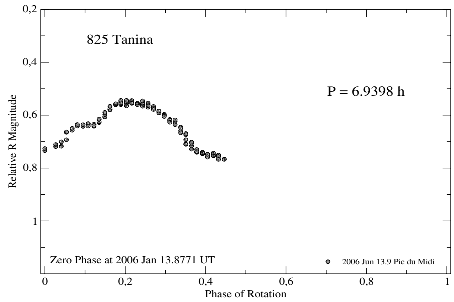

Fig. A.61. Composite lightcurve of 825 Tanina from its 2006 opposition.

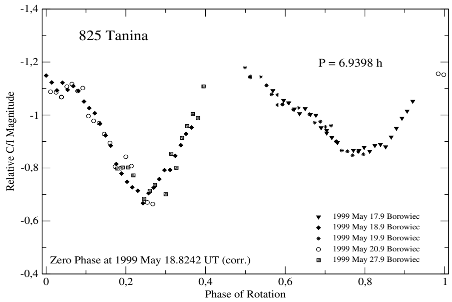

Fig. A.58. Composite lightcurve of 825 Tanina from its 1999 opposition.

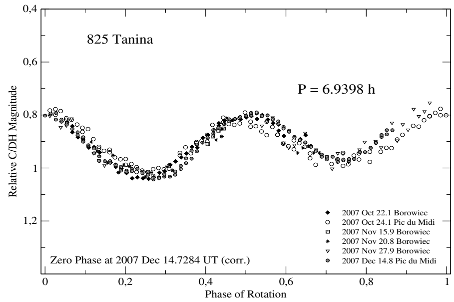

Fig. A.62. Composite lightcurve of 825 Tanina from its 2007 opposition.

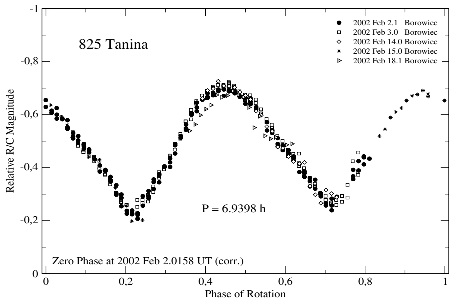

Fig. A.59. Composite lightcurve of 825 Tanina from its 2002 opposition.

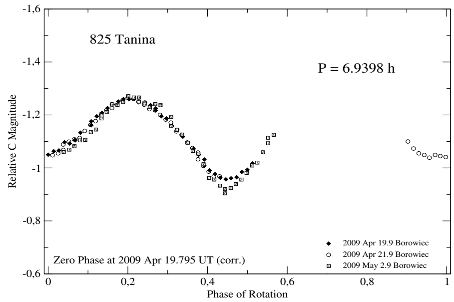

Fig. A.63. Composite lightcurve of 825 Tanina from its 2009 opposition.

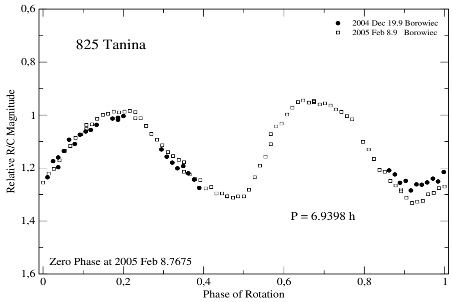

Fig. A.60. Composite lightcurve of 825 Tanina from its 2004/2005 opposition.

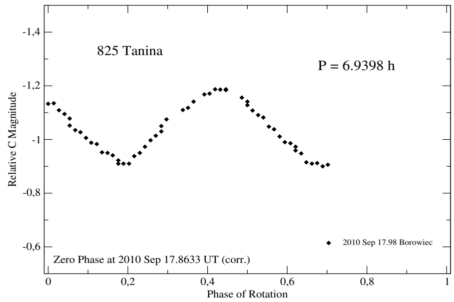

Fig. A.64. Composite lightcurve of 825 Tanina from its 2010 opposition.

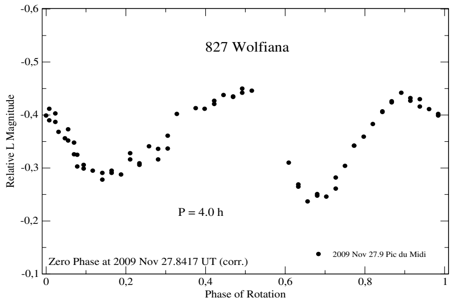

Fig. A.65. Composite lightcurve of 827 Wolfiana from its 2009 opposition.

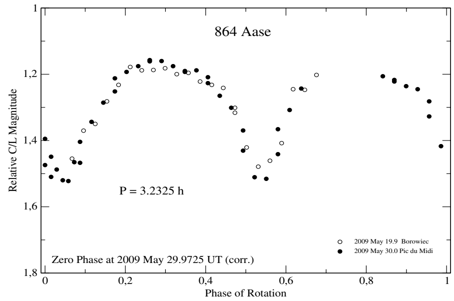

Fig. A.69. Composite lightcurve of 864 Aase from its 2009 opposition.

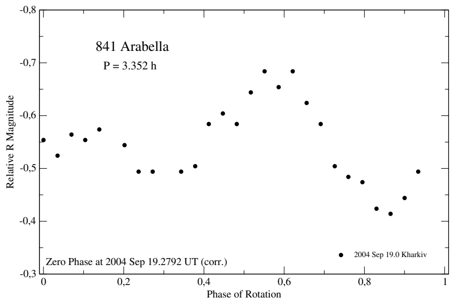

Fig. A.66. Composite lightcurve of 841 Arabella from its 2004 opposition.

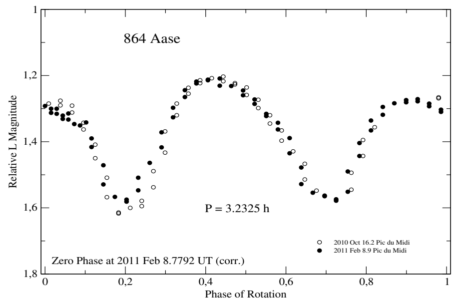

Fig. A.70. Composite lightcurve of 864 Aase from its 2010/2011 opposition.

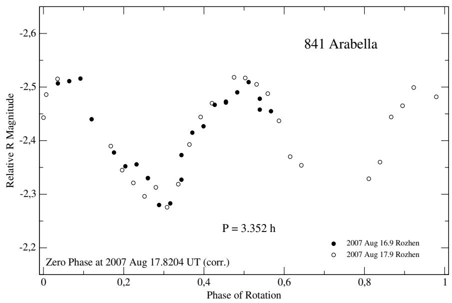

Fig. A.67. Composite lightcurve of 841 Arabella from its 2007 opposition.

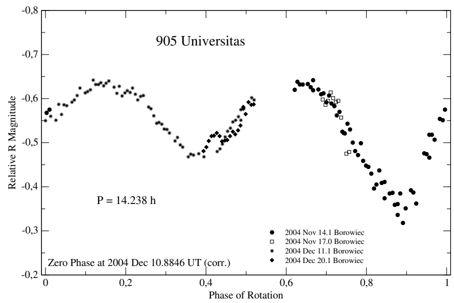

Fig. A.71. Composite lightcurve of 905 Universitas from 2004 opposition.

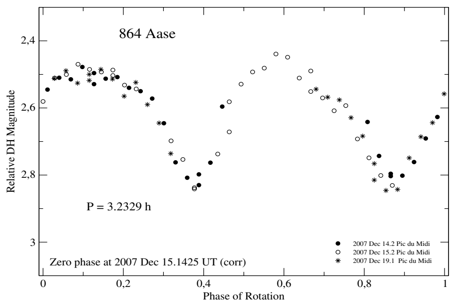

Fig. A.68. Composite lightcurve of 864 Aase from its 2007 opposition.

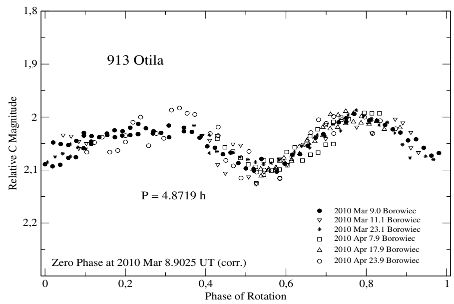

Fig. A.72. Composite lightcurve of 913 Otila from its 2010 opposition.

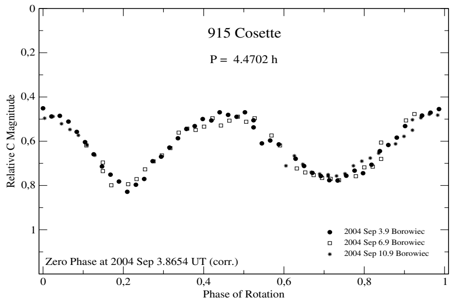

Fig. A.73. Composite lightcurve of 915 Cosette from its 2004 opposition.

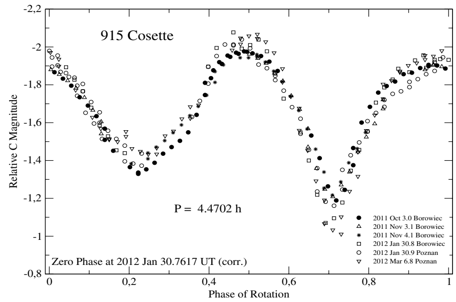

Fig. A.77. Composite lightcurve of 915 Cosette from its 2011/2012 opposition.

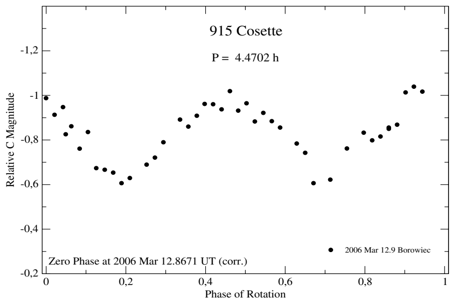

Fig. A.74. Composite lightcurve of 915 Cosette from its 2006 opposition.

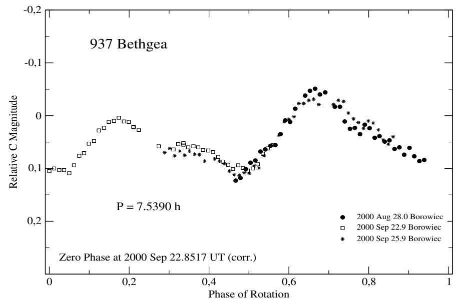

Fig. A.78. Composite lightcurve of 937 Bethgea from its 2000 opposition.

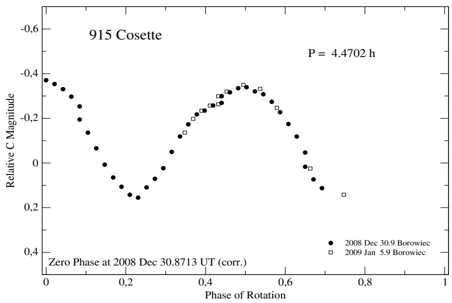

Fig. A.75. Composite lightcurve of 915 Cosette from its 2008 opposition.

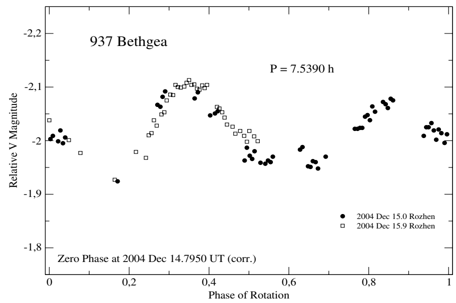

Fig. A.79. Composite lightcurve of 937 Bethgea from its 2004 opposition.

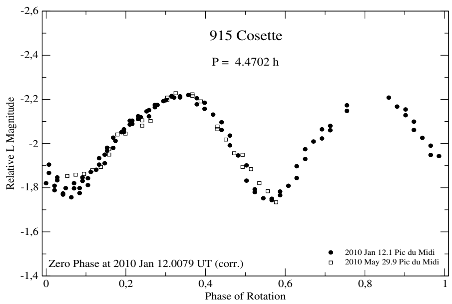

Fig. A.76. Composite lightcurve of 915 Cosette from its 2010 opposition.

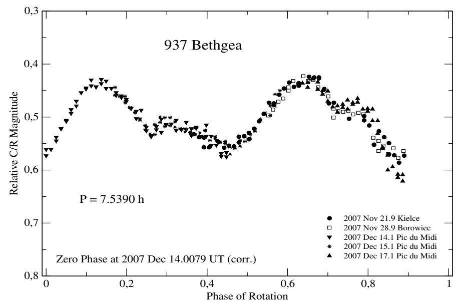

Fig. A.80. Composite lightcurve of 937 Bethgea from its 2007 opposition.

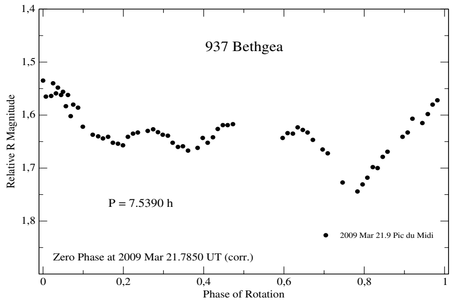

Fig. A.81. Composite lightcurve of 937 Bethgea from its 2009 opposition.

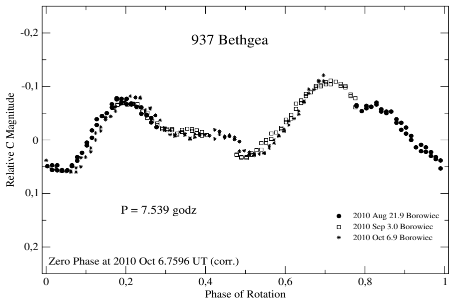

Fig. A.82. Composite lightcurve of 937 Bethgea from its 2010 opposition.

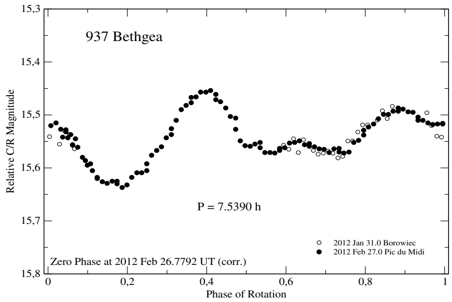

Fig. A.83. Composite lightcurve of 937 Bethgea from its 2012 opposition.

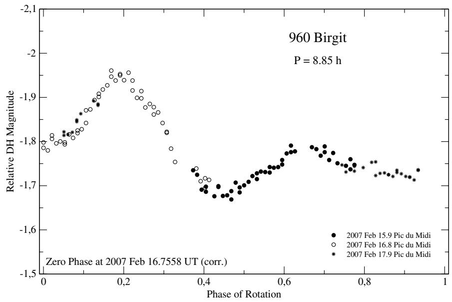

Fig. A.84. Composite lightcurve of 960 Birgit from its 2007 opposition.

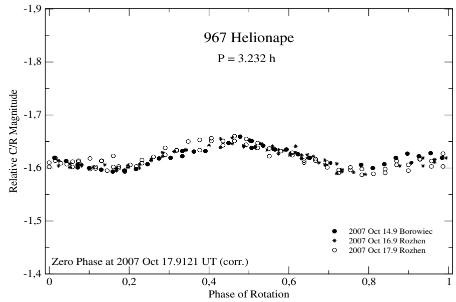

Fig. A.85. Composite lightcurve of 967 Helionape from its 2007 opposition.

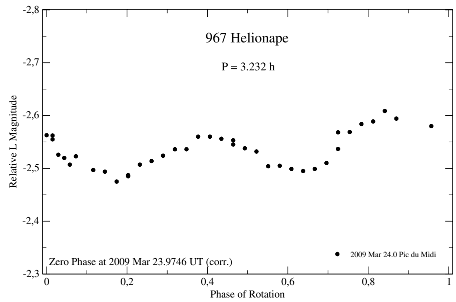

Fig. A.86. Composite lightcurve of 967 Helionape from its 2009 opposition.

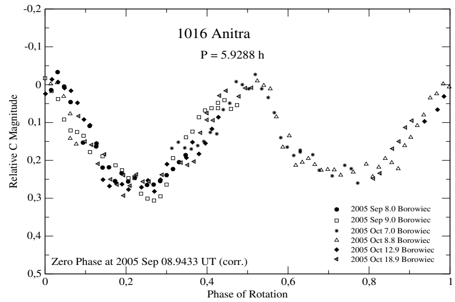

Fig. A.87. Composite lightcurve of 1016 Anitra from its 2005 opposition.

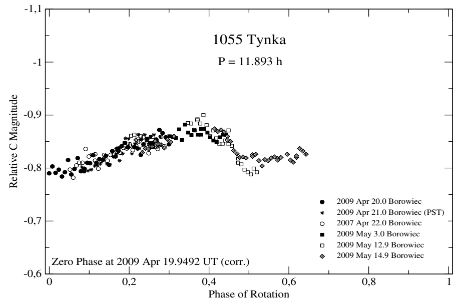

Fig. A.88. Composite lightcurve of 1055 Tynka from its 2009 opposition.

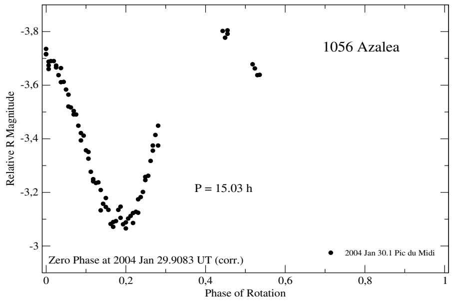

Fig. A.89. Composite lightcurve of 1056 Azalea from its 2004 opposition.

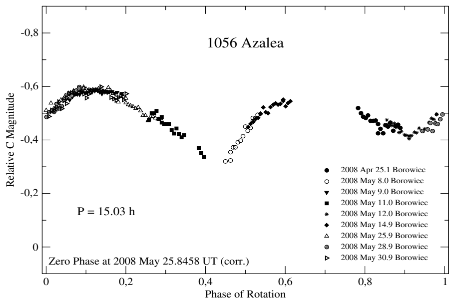

Fig. A.90. Composite lightcurve of 1056 Azalea from its 2008 opposition.

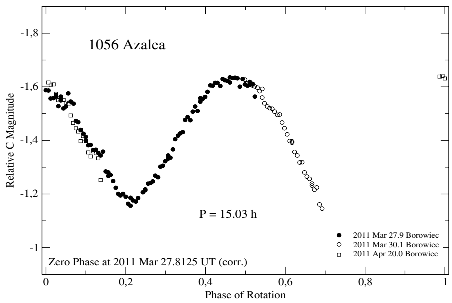

Fig. A.91. Composite lightcurve of 1056 Azalea from its 2011 opposition.

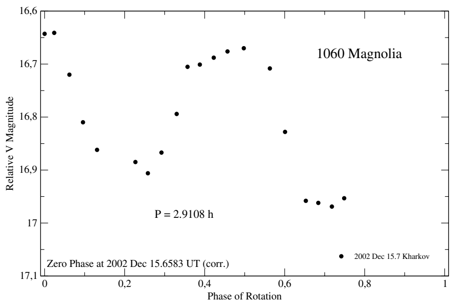

Fig. A.92. Composite lightcurve of 1060 Magnolia from its 2002 opposition.

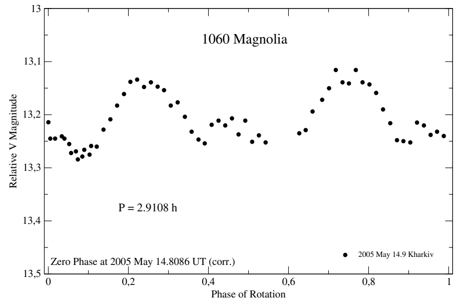

Fig. A.93. Composite lightcurve of 1060 Magnolia from its 2005 opposition.

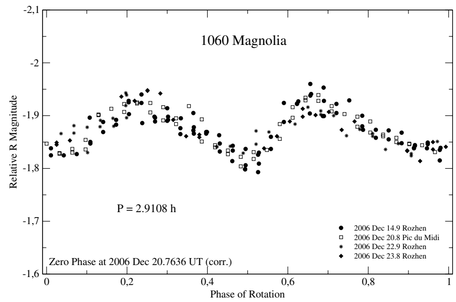

Fig. A.94. Composite lightcurve of 1060 Magnolia from its 2006 opposition.

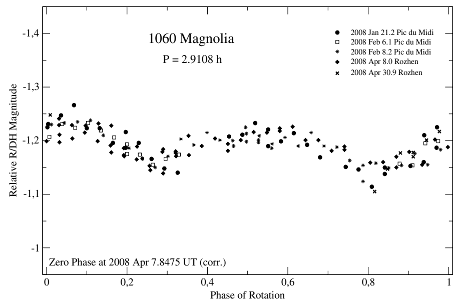

Fig. A.95. Composite lightcurve of 1060 Magnolia from its 2008 opposition.

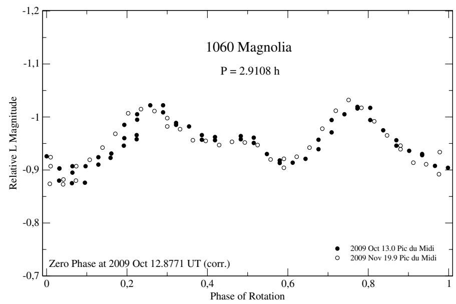

Fig. A.96. Composite lightcurve of 1060 Magnolia from its 2009 opposition.

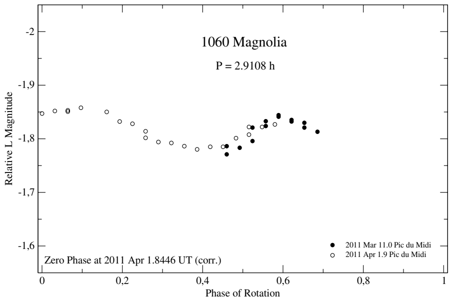

Fig. A.97. Composite lightcurve of 1060 Magnolia from its 2011 opposition.

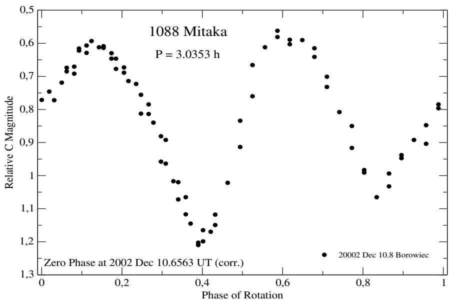

Fig. A.98. Composite lightcurve of 1088 Mitaka from its 2002 opposition.

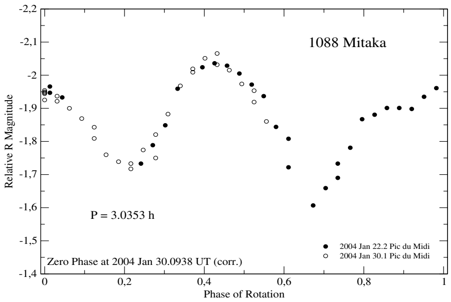

Fig. A.99. Composite lightcurve of 1088 Mitaka from its 2004 opposition.

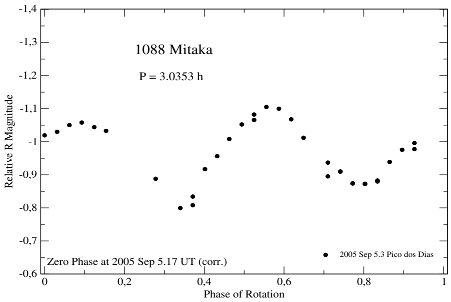

Fig. A.100. Composite lightcurve of 1088 Mitaka from its 2005 opposition.

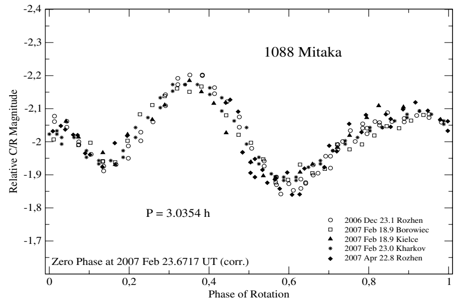

Fig. A.101. Composite lightcurve of 1088 Mitaka from its 2006/2007 opposition.

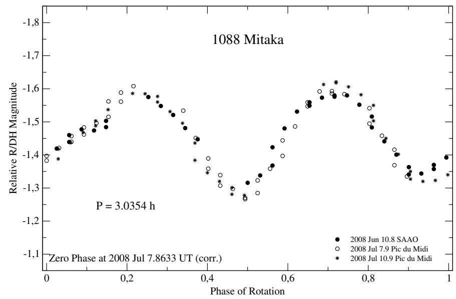

Fig. A.102. Composite lightcurve of 1088 Mitaka from its 2008 opposition.

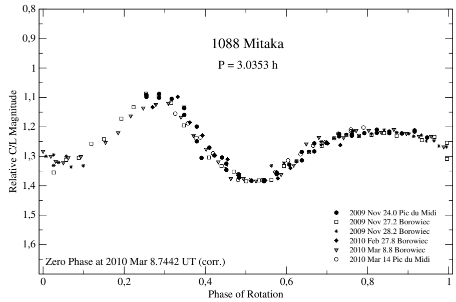

Fig. A.103. Composite lightcurve of 1088 Mitaka from its 2009/2010 opposition.

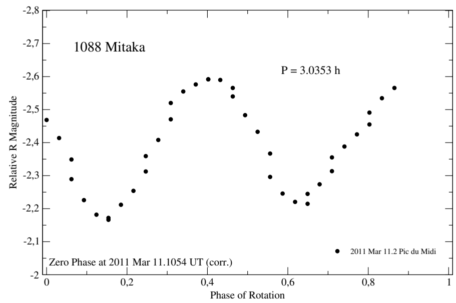

Fig. A.104. Composite lightcurve of 1088 Mitaka from its 2011 opposition.

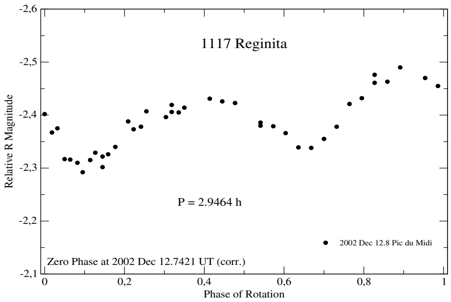

Fig. A.105. Composite lightcurve of 1117 Reginita from its 2002 opposition.

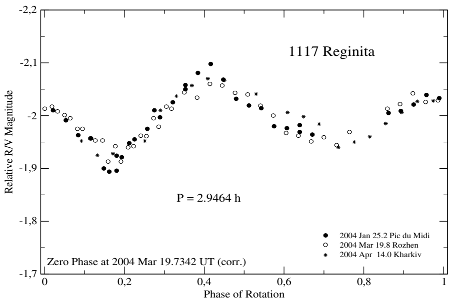

Fig. A.106. Composite lightcurve of 1117 Reginita from its 2004 opposition.

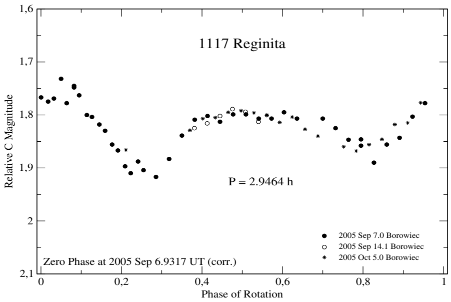

Fig. A.107. Composite lightcurve of 1117 Reginita from its 2005 opposition.

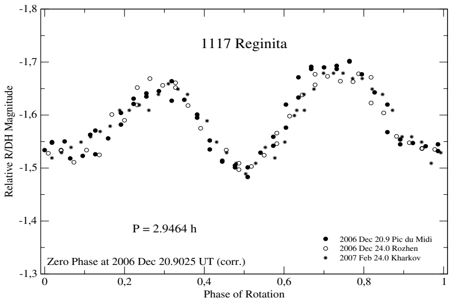

Fig. A.108. Composite lightcurve of 1117 Reginita from its 2006/2007 opposition.

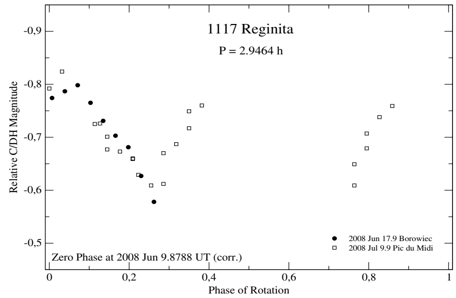

Fig. A.109. Composite lightcurve of 1117 Reginita from its 2008 opposition.

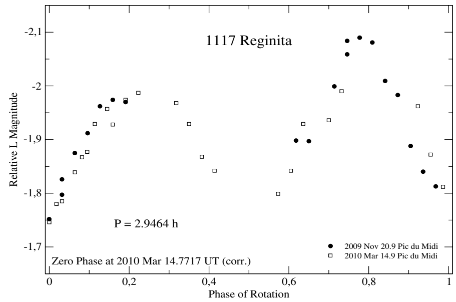

Fig. A.110. Composite lightcurve of 1117 Reginita from its 2009/2010 opposition.

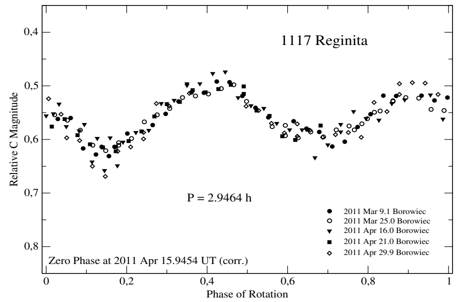

Fig. A.111. Composite lightcurve of 1117 Reginita from its 2011 opposition.

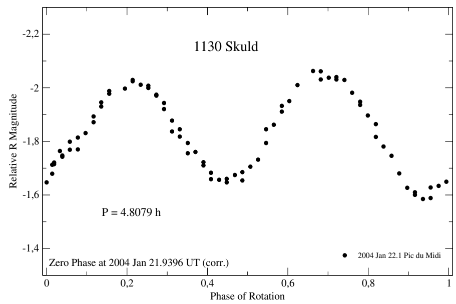

Fig. A.112. Composite lightcurve of 1130 Skuld from its 2004 opposition.

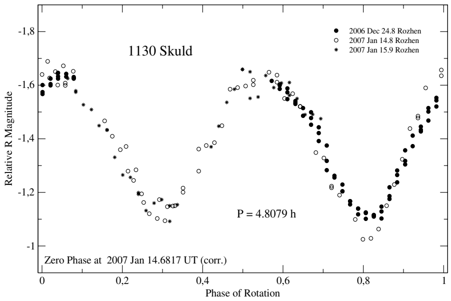

Fig. A.113. Composite lightcurve of 1130 Skuld from its 2006/2007 opposition.

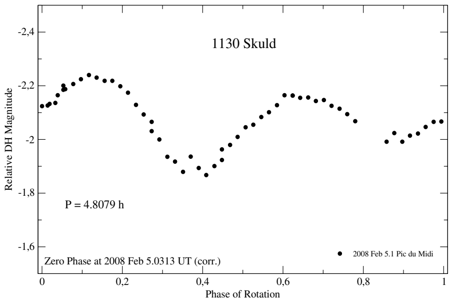

Fig. A.114. Composite lightcurve of 1130 Skuld from its 2008 opposition.

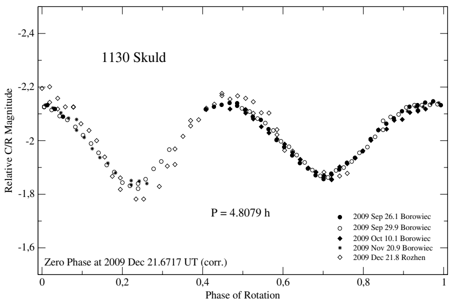

Fig. A.115. Composite lightcurve of 1130 Skuld from its 2009 opposition.

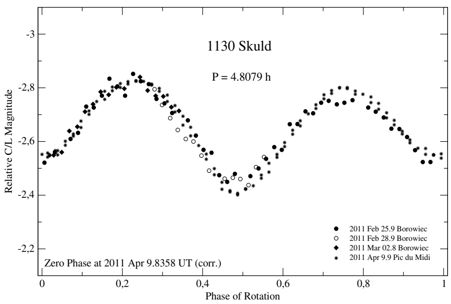

Fig. A.116. Composite lightcurve of 1130 Skuld from its 2011 opposition.

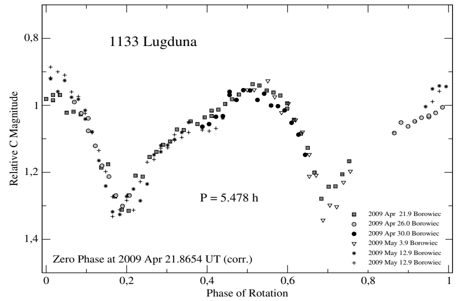

Fig. A.117. Composite lightcurve of 1133 Lugduna from its 2009 opposition.

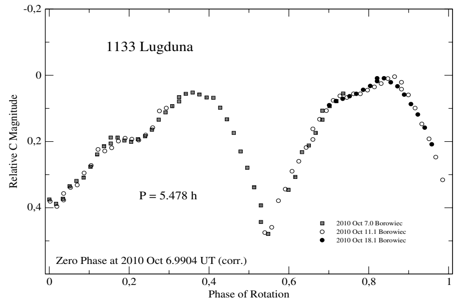

Fig. A.118. Composite lightcurve of 1133 Lugduna from its 2010 opposition.

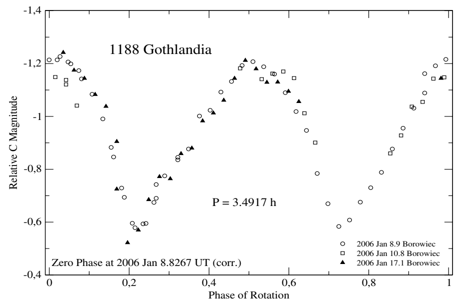

Fig. A.119. Composite lightcurve of 1188 Gothlandia from its 2006 opposition.

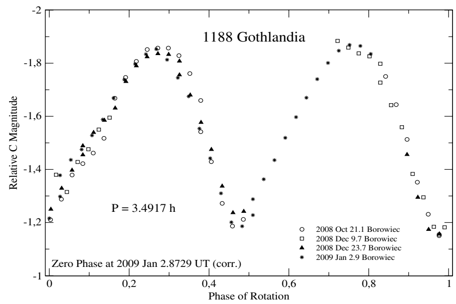

Fig. A.120. Composite lightcurve of 1188 Gothlandia from its 2008/2009 opposition.

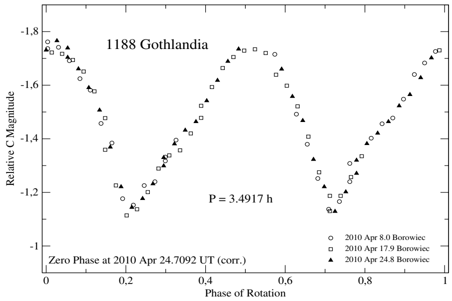

Fig. A.121. Composite lightcurve of 1188 Gothlandia from its 2010 opposition.

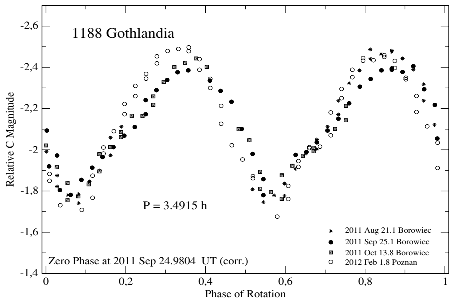

Fig. A.122. Composite lightcurve of 1188 Gothlandia from its 2011/2012 opposition.

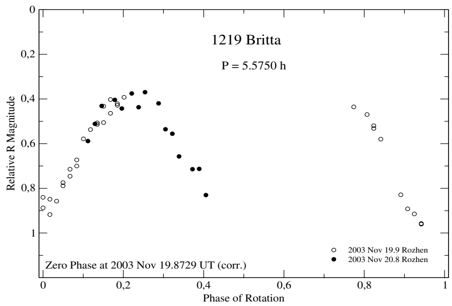

Fig. A.123. Composite lightcurve of 1219 Britta from its 2003 opposition.

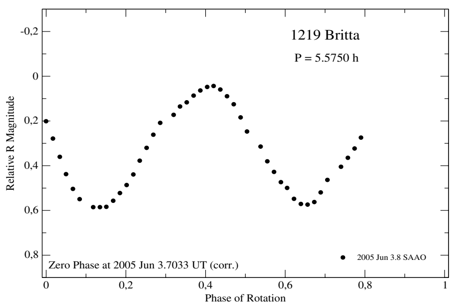

Fig. A.124. Composite lightcurve of 1219 Britta from its 2005 opposition.

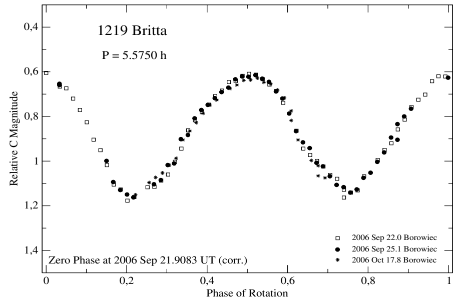

Fig. A.125. Composite lightcurve of 1219 Britta from its 2006 oppositio

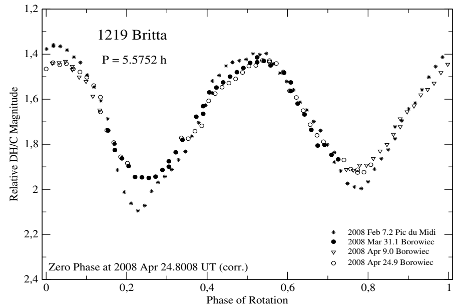

Fig. A.126. Composite lightcurve of 1219 Britta from its 2008 opposition.

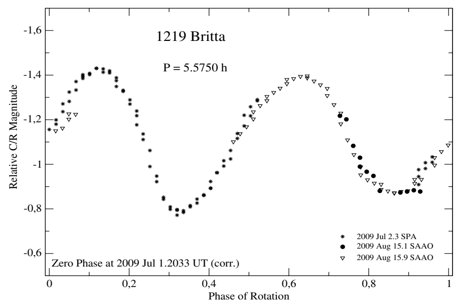

Fig. A.127. Composite lightcurve of 1219 Britta from its 2009 opposition.

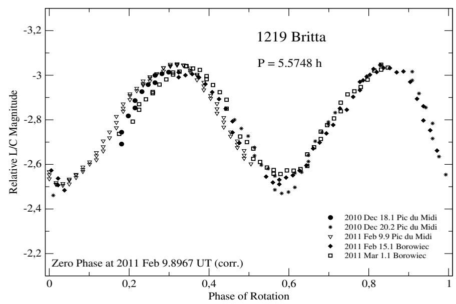

Fig. A.128. Composite lightcurve of 1219 Britta from its 2010/2011 opposition.

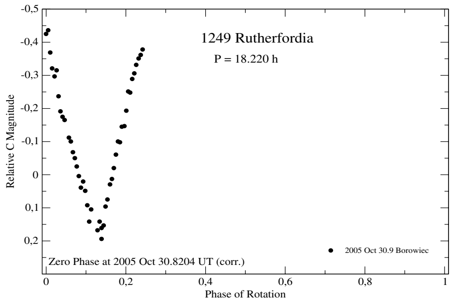

Fig. A.129. Composite lightcurve of 1249 Rutherfordia from its 2005 opposition.

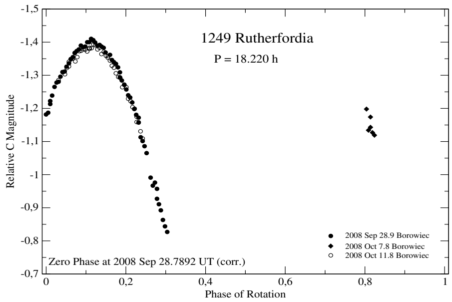

Fig. A.130. Composite lightcurve of 1249 Rutherfordia from its 2008 opposition.

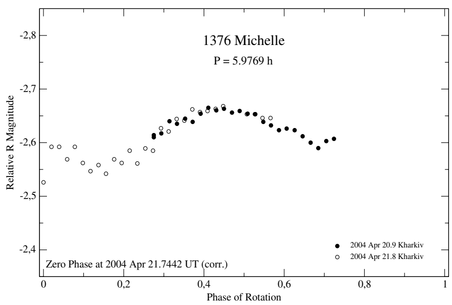

Fig. A.131. Composite lightcurve of 1376 Michelle from its 2004 opposition.

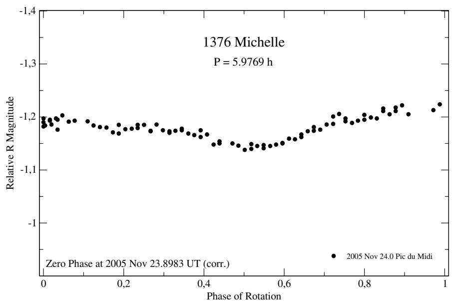

Fig. A.132. Composite lightcurve of 1376 Michelle from its 2005 opposition.

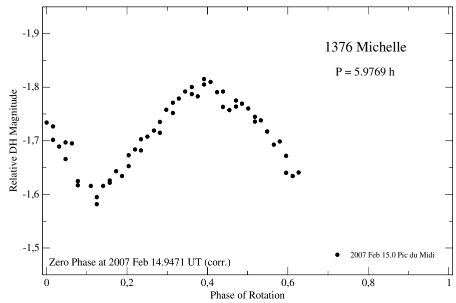

Fig. A.133. Composite lightcurve of 1376 Michelle from its 2007 opposition.

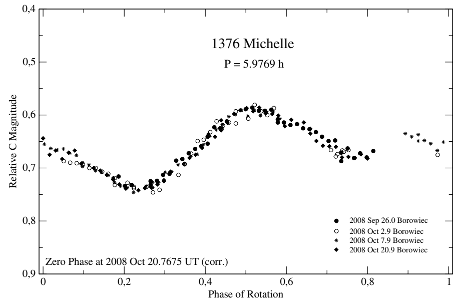

Fig. A.134. Composite lightcurve of 1376 Michelle from its 2008 opposition.

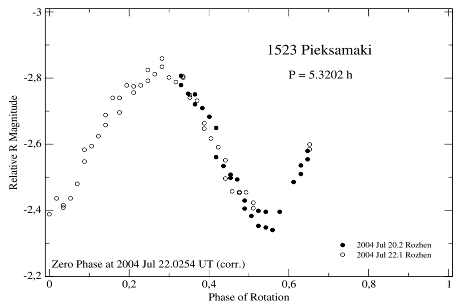

Fig. A.135. Composite lightcurve of 1523 Pieksamaki from its 2004 opposition.

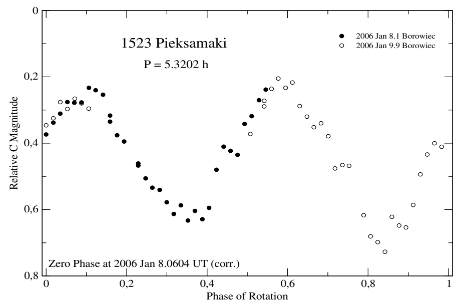

Fig. A.136. Composite lightcurve of 1523 Pieksamaki from its 2006 opposition.

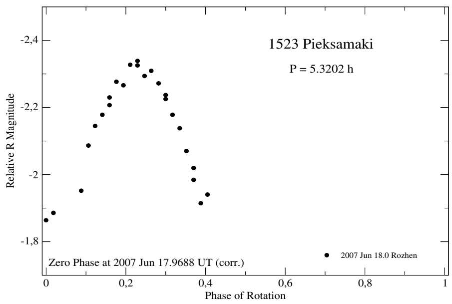

Fig. A.137. Composite lightcurve of 1523 Pieksamaki from its 2007 opposition.

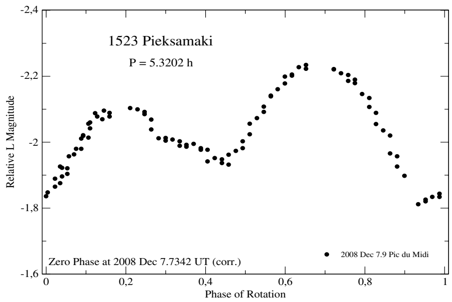

Fig. A.138. Composite lightcurve of 1523 Pieksamaki from its 2008 opposition.

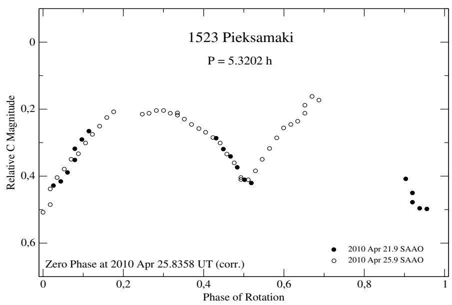

Fig. A.139. Composite lightcurve of 1523 Pieksamaki from its 2010 opposition.

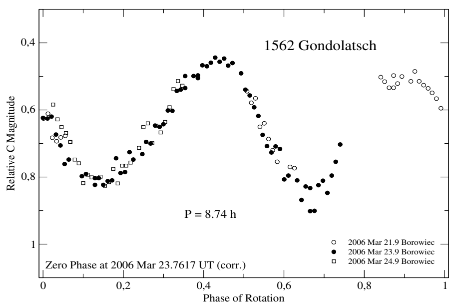

Fig. A.140. Composite lightcurve of 1562 Gondolatsch from its 2006 opposition.

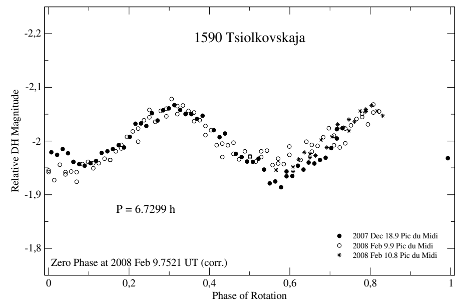

Fig. A.141. Composite lightcurve of 1590 Tsiolkovskaja from its 2007/2008 opposition.

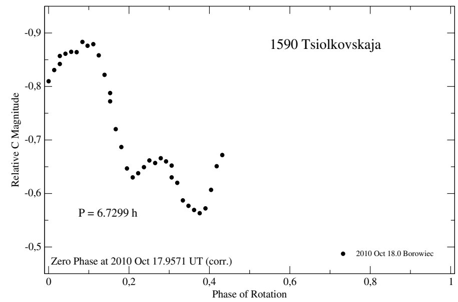

Fig. A.142. Composite lightcurve of 1590 Tsiolkovskaja from its 2010 opposition.

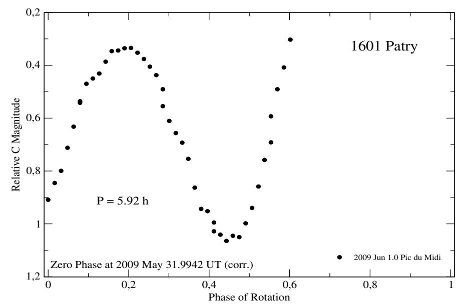

Fig. A.143. Composite lightcurve of 1601 Patry from its 2009 opposition.

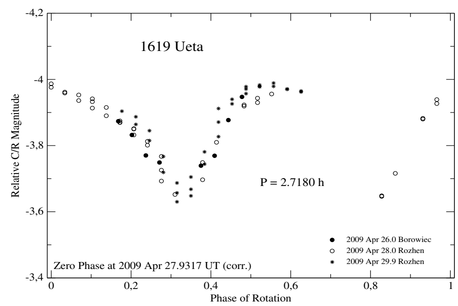

Fig. A.144. Composite lightcurve of 1619 from its 2009 opposition.

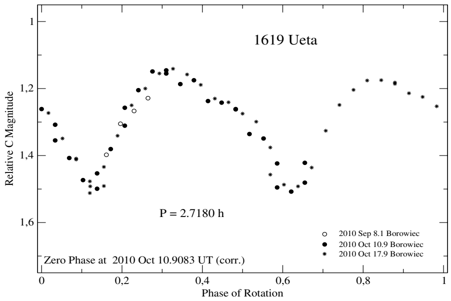

Fig. A.145. Composite lightcurve of 1619 from its 2010 opposition.

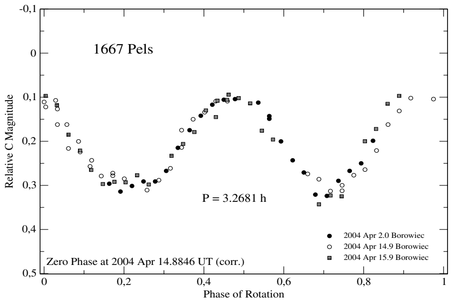

Fig. A.146. Composite lightcurve of 1667 Pels from its 2004 opposition.

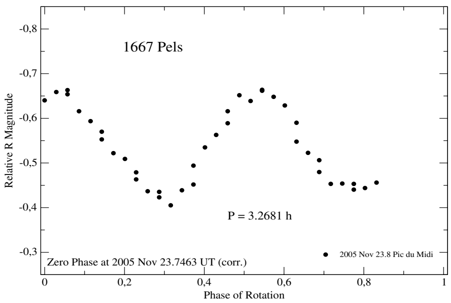

Fig. A.147. Composite lightcurve of 1667 Pels from its 2005 opposition.

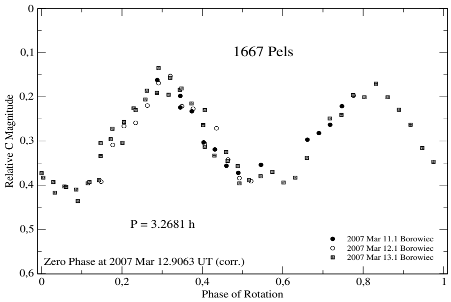

Fig. A.148. Composite lightcurve of 1667 Pels from its 2007 opposition.

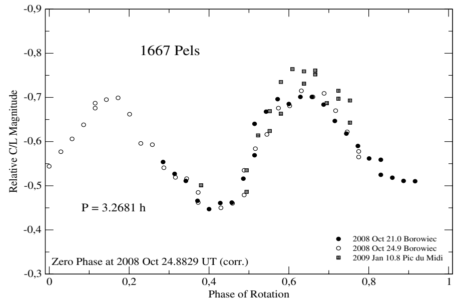

Fig. A.149. Composite lightcurve of 1667 Pels from its 2008/2009 opposition.

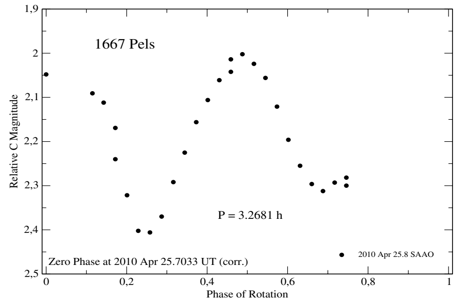

Fig. A.150. Composite lightcurve of 1667 Pels from its 2010 opposition.

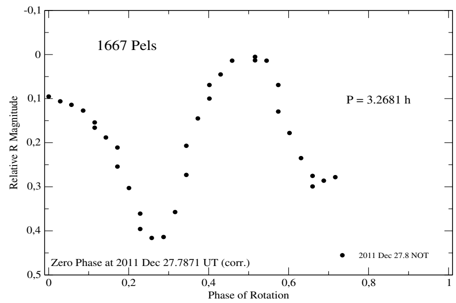

Fig. A.151. Composite lightcurve of 1667 Pels from its 2011 opposition.

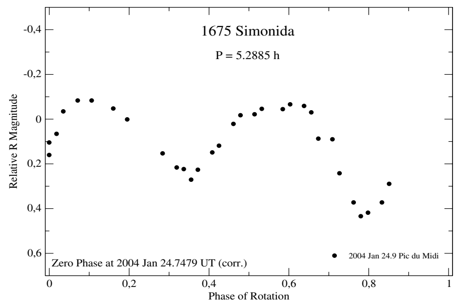

Fig. A.152. Composite lightcurve of 1675 Simonida from its 2004 opposition.

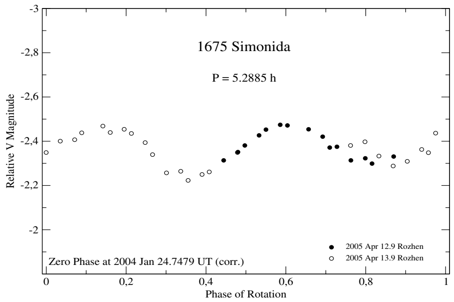

Fig. A.153. Composite lightcurve of 1675 Simonida from its 2005 opposition.

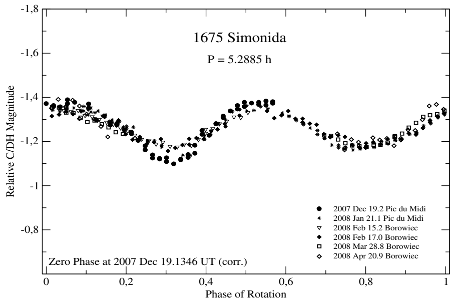

Fig. A.154. Composite lightcurve of 1675 Simonida from its 2007/2008 opposition.

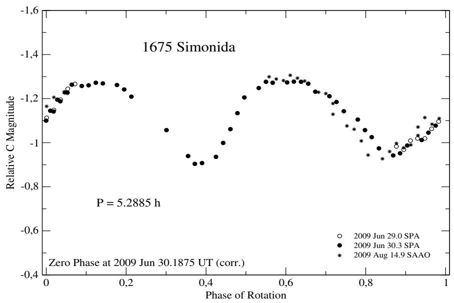

Fig. A.155. Composite lightcurve of 1675 Simonida from its 2009 opposition.

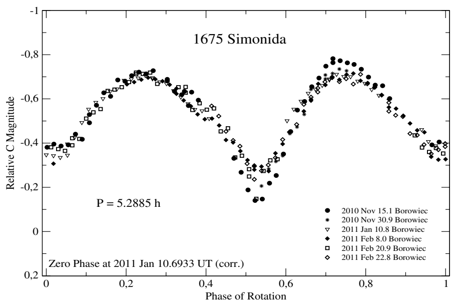

Fig. A.156. Composite lightcurve of 1675 Simonida from its 2010/2011 opposition.

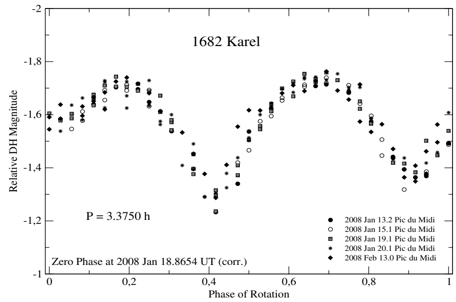

Fig. A.157. Composite lightcurve of 1682 Karel from its 2008 opposition.

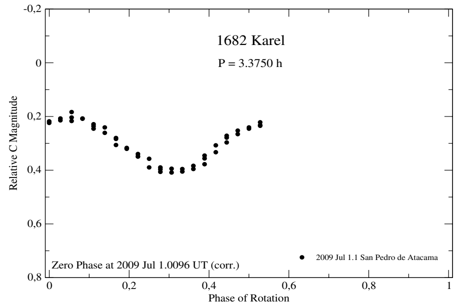

Fig. A.158. Composite lightcurve of 1682 Karel from its 2009 opposition.

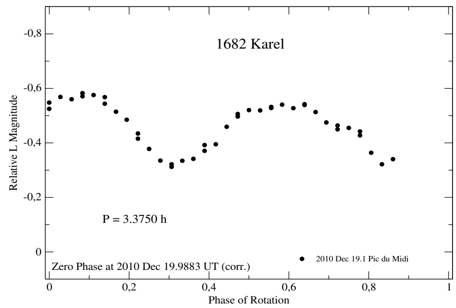

Fig. A.159. Composite lightcurve of 1682 Karel from its 2010 opposition.

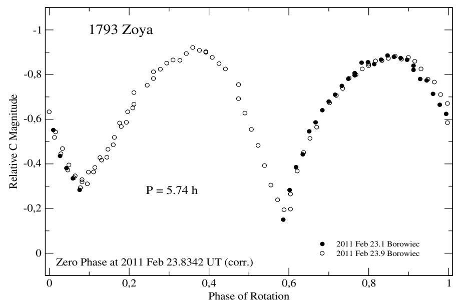

Fig. A.160. Composite lightcurve of 1793 Zoya from its 2011 opposition.

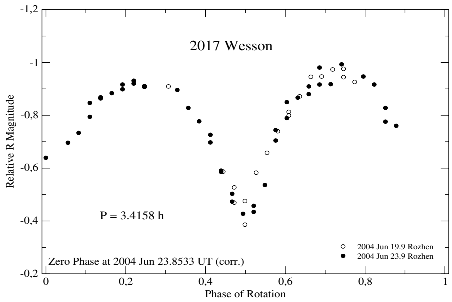

Fig. A.161. Composite lightcurve of 2017 Wesson from its 2004 opposition.

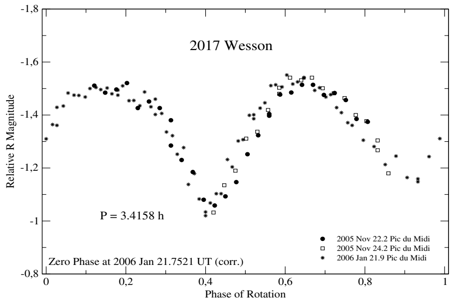

Fig. A.162. Composite lightcurve of 2017 Wesson from its 2005/2006 opposition.

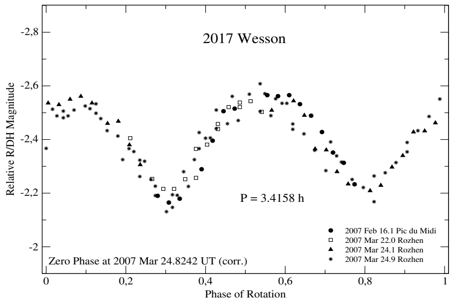

Fig. A.163. Composite lightcurve of 2017 Wesson from its 2007 opposition.

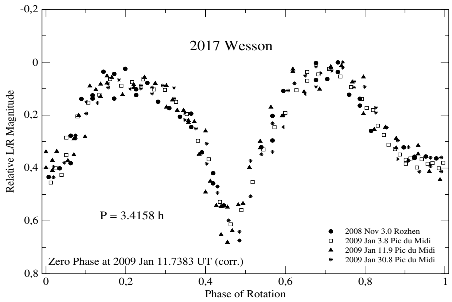

Fig. A.164. Composite lightcurve of 2017 Wesson from its 2008/2009 opposition.

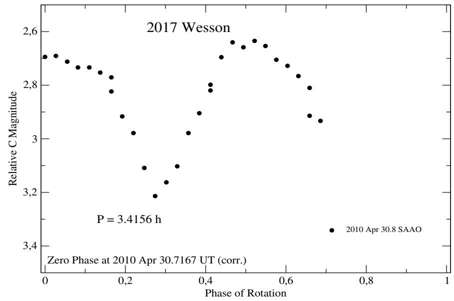

Fig. A.165. Composite lightcurve of 2017 Wesson from its 2010 opposition.

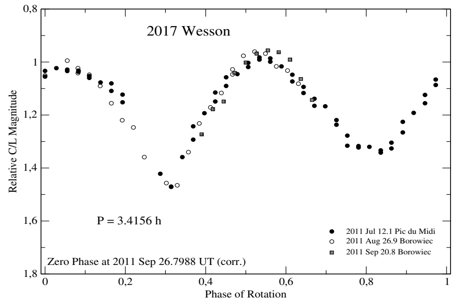

Fig. A.166. Composite lightcurve of 2017 Wesson from its 2011 opposition.

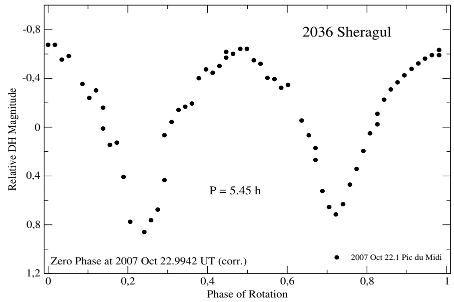

Fig. A.167. Composite lightcurve of 2036 Sheragul from its 2007 opposition.

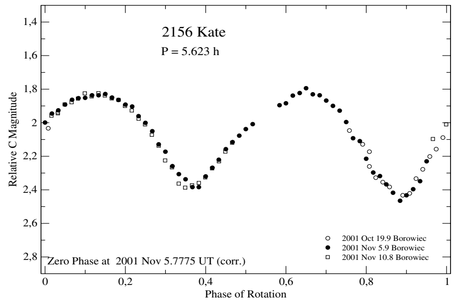

Fig. A.168. Composite lightcurve of 2156 Kate from its 2001 opposition.

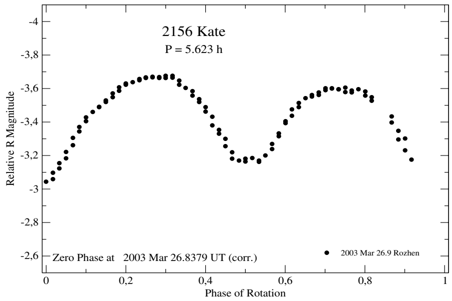

Fig. A.169. Composite lightcurve of 2156 Kate from its 2003 opposition.

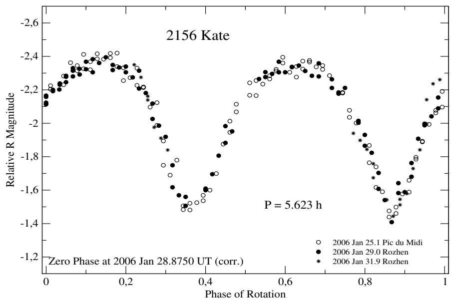

Fig. A.170. Composite lightcurve of 2156 Kate from its 2006 opposition.

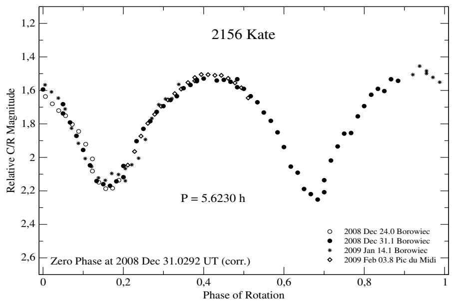

Fig. A.171. Composite lightcurve of 2156 Kate from its 2008/2009 opposition.

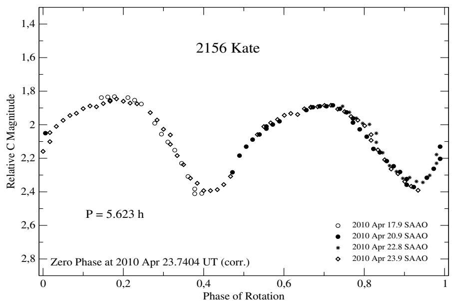

Fig. A.172. Composite lightcurve of 2156 Kate from its 2010 opposition.

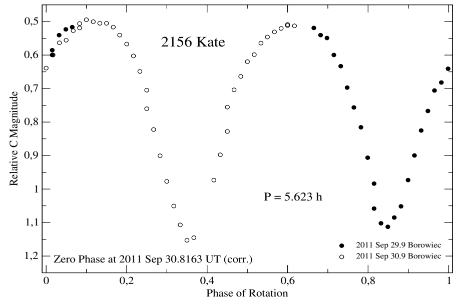

Fig. A.173. Composite lightcurve of 2156 Kate from its 2011 opposition.

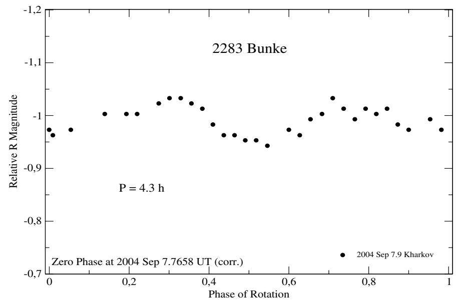

Fig. A.174. Composite lightcurve of 2283 Bunke from its 2004 opposition.

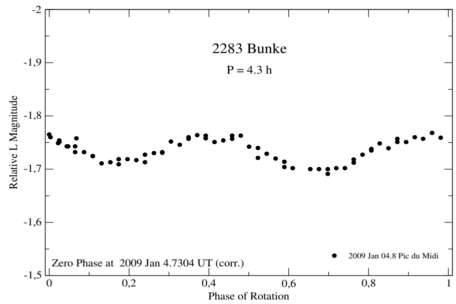

Fig. A.175. Composite lightcurve of 2283 Bunke from its 2009 opposition.

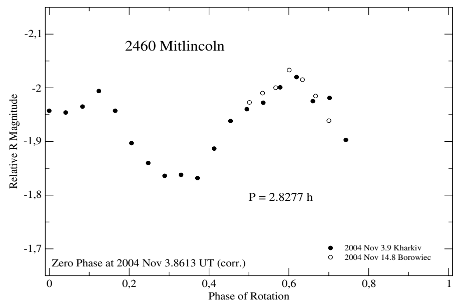

Fig. A.176. Composite lightcurve of 2460 Mitlincoln its from 2004 opposition.

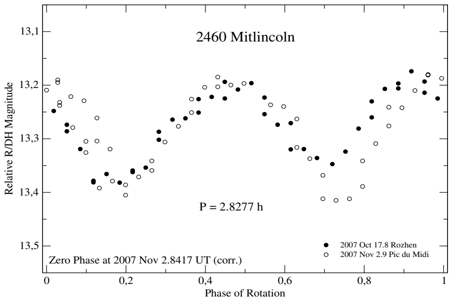

Fig. A.177. Composite lightcurve of 2460 Mitlincoln from its 2007 opposition.

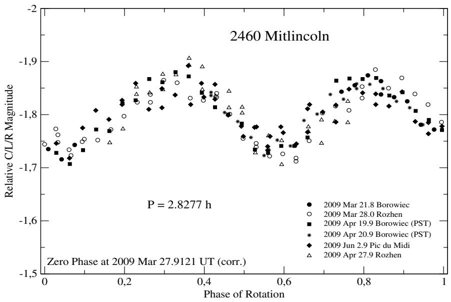

Fig. A.178. Composite lightcurve of 2460 Mitlincoln from its 2009 opposition.

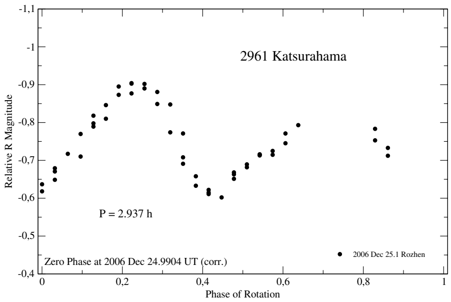

Fig. A.179. Composite lightcurve of 2961 Katsurahama from its 2006 opposition.

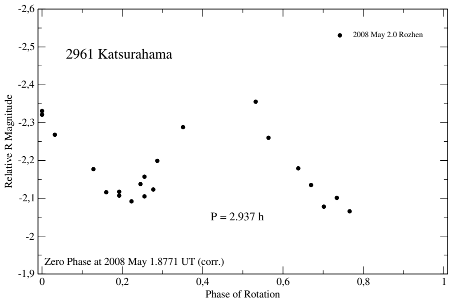

Fig. A.180. Composite lightcurve of 2961 Katsurahama from its 2008 opposition.

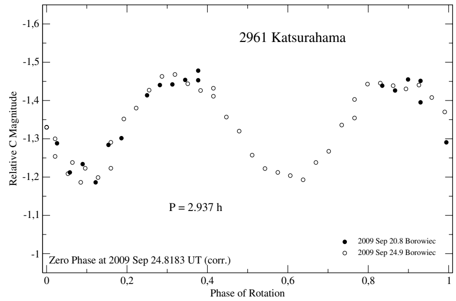

Fig. A.181. Composite lightcurve of 2961 Katsurahama from its 2009 opposition.

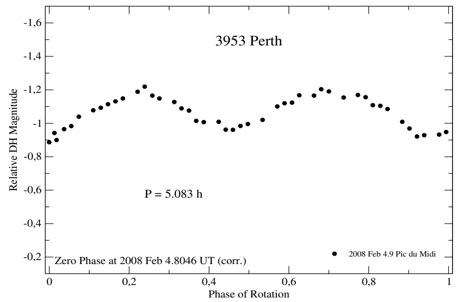

Fig. A.182. Composite lightcurve of 3953 Perth from its 2008 opposition.

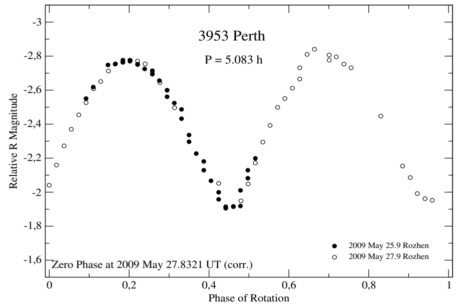

Fig. A.183. Composite lightcurve of 3953 Perth from its 2009 opposition.

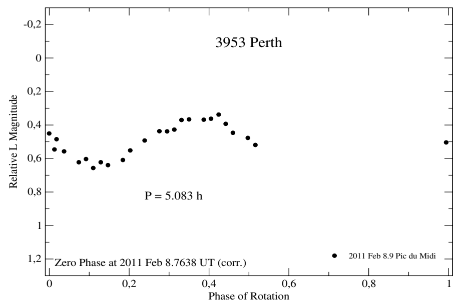

Fig. A.184. Composite lightcurve of 3953 Perth from its 2011 opposition.

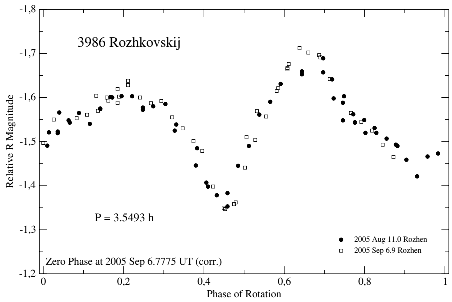

Fig. A.185. Composite lightcurve of 3986 Rozhkovskij from its 2005 opposition.

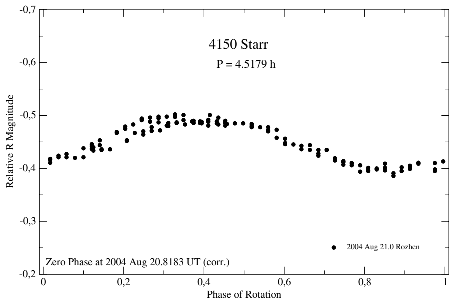

Fig. A.186. Composite lightcurve of 4150 Starr from its 2004 opposition.

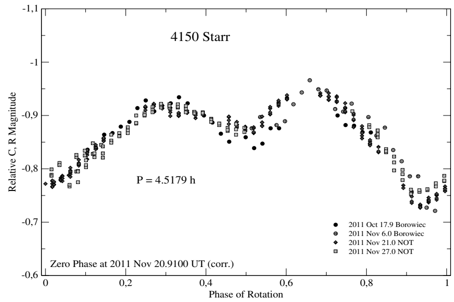

Fig. A.187. Composite lightcurve of 4150 Starr from its 2011 opposition.

Table A.1. Aspect data.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (J2000) (°)	Obs
281 Lucretia						
2003 Mar. 29.94	2.3520	1.3823	7.58	171.37	4.91	Roz
2006 Jan. 28.15	2.1439	1.1871	8.39	144.17	9.28	Bor
2006 Feb. 23.81	2.1852	1.2289	8.90	136.97	8.68	Bor
2008 Dec. 15.86	1.9625	1.0018	8.74	99.45	9.06	Bor
2008 Dec. 23.87	1.9712	0.9961	5.27	97.33	9.41	Bor
2009 Jan. 2.79	1.9827	1.0112	6.12	94.63	9.61	Bor
2009 Jan. 13.07	1.9953	1.0519	11.01	92.20	9.53	Bor
2011 Sep. 30.0	1.9124	1.0414	20.20	47.72	–0.69	Bor
2011 Nov. 3.97	1.8996	1.9079	1.01	41.63	1.89	Bor
291 Alice						
1999 Mar. 25.85	2.0476	1.1232	14.17	154.57	0.41	Bor
1999 Apr. 1.94	2.0522	1.1703	17.44	153.77	0.54	Bor
2004 Oct. 22.09	2.2201	1.2504	7.71	46.21	–2.76	Bor
2004 Nov. 16.92	2.1924	1.2242	7.01	39.47	–3.00	Bor
2007 Oct. 3.94	2.3491	1.3694	6.49	354.85	–1.07	Bor
2007 Oct. 7.87	2.3459	1.3825	8.47	353.93	–1.11	Bor
2007 Oct. 14.85	2.3400	1.4155	11.80	352.48	–1.17	Bor
2007 Oct. 15.83	2.3391	1.4213	12.26	352.29	–1.18	Bor
2007 Nov. 16.82	2.3107	1.6920	22.49	350.68	–1.32	Pic
2009 Feb. 9.13	2.0355	1.1697	17.65	179.20	–0.01	Bor
298 Baptistina						
2008 Apr. 23.55	2.1598	1.1627	4.74	204.35	–4.06	HH
2008 Apr. 24.55	2.1608	1.1655	5.02	204.10	–4.11	HH
2008 Apr. 25.60	2.1619	1.1687	5.58	203.85	–4.17	HH
2008 Apr. 28.61	2.1649	1.1793	7.41	203.14	–4.31	HH
2008 May 7.14	2.1746	1.2269	12.18	201.24	–4.70	PdD
2008 May 7.89	2.1744	1.2252	12.07	201.28	–4.69	Bor
2008 May 8.09	2.1746	1.2264	12.16	201.25	–4.70	PdD
2008 May 8.91	2.1754	1.2314	12.55	201.11	–4.72	Bor
2008 May 11.89	2.1785	1.2507	13.90	200.66	–4.81	Bor
352 Gisela						
2004 Mar. 20.02	2.4767	1.4907	4.20	188.97	–4.98	Roz
2005 Jul. 3.05	2.1423	1.2484	17.04	319.10	4.74	LE
2005 Jul. 9.03	2.1318	1.2000	14.62	318.51	5.01	LE
2005 Jul. 11.02	2.1283	1.1853	13.73	318.25	5.11	LE
2005 Aug. 6.98	2.0812	1.0702	3.11	312.39	6.01	LE
2005 Sep. 6.86	2.0292	1.1420	18.06	306.09	5.85	Bor
2005 Sep. 7.87	2.0275	1.1474	18.50	306.00	5.82	Bor
2005 Sep. 8.86	2.0259	1.1530	18.92	305.91	5.80	Bor
2005 Sep. 13.86	2.0179	1.1833	20.93	305.63	5.66	Bor
2005 Sep. 19.82	2.0084	1.2238	23.06	305.59	5.49	Bor
2007 Mar. 12.00	2.3682	1.4047	7.60	153.52	–5.70	Bor
2007 Mar. 13.90	2.3708	1.4145	8.48	153.07	–5.66	Kie
2007 Mar. 13.93	2.3709	1.4147	8.50	153.06	–5.66	Bor
2007 Mar. 15.92	2.3736	1.4260	9.41	152.62	–5.62	Bor
2008 Jul. 6.94	2.2902	1.2944	6.84	269.90	2.91	Pic
2008 Jul. 8.96	2.2870	1.2982	7.87	269.41	2.95	Pic
2010 Feb. 25.88	2.2016	1.3785	18.16	113.49	–4.86	Bor
2010 Mar. 10.92	2.2240	1.5196	21.96	113.49	–4.59	Bor
2010 Mar. 22.92	2.2442	1.6700	24.23	114.66	–4.32	Bor
364 Isara						
2005 Jan. 16.88	1.9435	1.0778	18.57	77.89	–1.75	Bor
2005 Feb. 7.84	1.9692	1.2829	18.47	78.99	–0.16	Bor
2005 Feb. 9.92	1.9719	1.3052	18.91	79.30	–0.04	Bor
2005 Feb. 11.89	1.9743	1.3256	19.01	79.62	0.07	Bor
2005 Mar. 9.87	2.0103	1.6319	29.36	86.34	1.28	Bor
2005 Mar. 21.85	2.0283	1.7806	29.41	90.52	1.68	Bor
2006 Apr. 21.01	2.5435	1.6123	10.71	237.71	8.08	Bor

Notes. Columns give dates of observations with respect to the middle of the lightcurve, asteroid distances to the Sun (r) and the Earth (Δ) in AU, phase angle (α), observer-centred ecliptic longitude (λ) and latitude (β) for J2000.0, and the observatory code (Obs).

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (J2000) (°)	Obs
2006 Apr. 25.01	2.5448	1.5908	9.10	236.88	8.12	Bor
2006 Apr. 26.01	2.5451	1.5860	8.70	236.66	8.12	Bor
2006 May 4.01	2.5473	1.5571	5.47	234.75	8.11	Bor
2006 May 5.01	2.5476	1.5547	5.09	234.50	8.10	Bor
2006 May 11.01	2.5489	1.5457	3.34	232.94	8.02	Bor
2009 Apr. 01.07	2.4412	1.4576	5.36	200.00	10.09	Bor
2009 Apr. 3.06	2.4435	1.4561	4.78	199.47	10.10	Bor
2009 Apr. 14.96	2.4570	1.4700	5.41	196.26	10.04	Bor
2009 Apr. 16.98	2.4592	1.4761	6.10	195.73	10.00	Bor
367 Amicitia						
2000 Oct. 23.05	2.2494	1.2632	4.46	39.28	–3.92	Bor
2000 Oct. 24.02	2.2484	1.2606	3.98	39.03	–3.91	Bor
2003 Jul. 22.08	2.4137	1.7851	22.18	2.53	–3.88	Pic
2003 Sep. 24.94	2.3781	1.3829	3.96	353.50	–5.06	Roz
2005 Mar. 10.04	2.0288	1.0393	3.35	165.73	5.72	Bor
2005 Mar. 30.00	2.0407	1.1067	13.51	161.34	5.43	Bor
2005 Apr. 11.92	2.0495	1.1941	19.22	160.02	5.03	Bor
2008 Jan. 4.09	2.0384	1.0556	1.17	104.48	1.96	Bor
2008 Jan. 10.90	2.0342	1.0554	3.69	102.65	2.18	Bor
2008 Jan. 14.78	2.0320	1.0607	6.04	101.63	2.29	Bor
2008 Feb. 3.81	2.0217	1.1432	16.89	97.83	2.69	Bor
2008 Mar. 27.80	2.0073	1.6292	29.59	104.19	2.79	Bor
2009 Jun. 27.08	2.3719	1.3573	2.06	280.21	–1.29	SPA
2009 Jun. 30.09	2.3740	1.3576	0.72	279.42	–1.36	SPA
2010 Sep. 23.02	2.2527	1.5436	21.96	56.90	–3.23	Bor
428 Monachia						
2009 Oct. 8.90	1.9085	0.9097	0.98	17.59	–0.28	Bor
2009 Nov. 21.71	1.8965	1.0872	22.74	11.67	3.10	Bor
2011 Mar. 29.04	2.6160	1.6945	9.94	188.10	3.22	Bor
453 Tea						
2005 Oct. 28.16	2.4107	1.6602	18.74	85.71	6.63	Bor
2005 Oct. 29.03	2.4104	1.6514	18.49	85.67	6.68	Bor
2005 Oct. 30.15	2.4100	1.6404	18.17	85.62	6.75	Bor
2006 Jan. 8.73	2.3729	1.5223	14.91	70.67	8.32	Bor
2008 Oct. 3.09	2.4152	1.6317	18.04	58.49	3.94	Bor
2008 Oct. 13.84	2.4176	1.5434	14.29	57.35	4.52	Bor
2008 Oct. 21.82	2.4189	1.4924	10.98	55.94	4.94	Bor
2008 Oct. 23.91	2.4193	1.4815	10.06	55.50	5.05	Bor
2008 Nov. 9.73	2.4208	1.4345	2.76	51.20	5.77	Bor
2008 Nov. 28.85	2.4206	1.4765	8.67	46.12	6.18	Bor
2008 Dec. 14.76	2.4189	1.5829	15.25	43.26	6.18	Bor
2008 Dec. 30.77	2.4158	1.7385	20.03	42.35	5.97	Bor
2010 Apr. 19.91	1.9669	0.9700	5.16	199.89	–2.54	Bor
2010 Apr. 30.93	1.9610	0.9947	11.70	197.41	–3.23	SAAO
2011 Oct. 01.06	2.3741	1.4075	8.21	27.30	1.17	Bor
2011 Oct. 01.86	2.3747	1.4050	7.82	27.11	1.20	Bor
2011 Oct. 17.06	2.3846	1.3881	0.79	23.06	1.86	Bor
540 Rosamunde						
2004 Oct. 21.96	2.3213	1.4852	16.72	70.82	–4.61	Bor
2004 Oct. 23.03	2.3204	1.4757	16.34	70.72	–4.67	Bor
2007 Oct. 16.86	2.3975	1.4007	0.33	23.85	–0.20	Kie
2009 Apr. 25.91	2.0279	1.1221	16.69	180.44	–0.93	Bor
2009 Apr. 30.90	2.0296	1.1560	18.85	180.04	–0.60	Bor
2009 May 5.89	2.0307	1.1783	20.04	179.91	–0.41	Bor
2010 Sep. 5.89	2.4106	1.4068	2.90	347.12	5.75	Bor
2010 Sep. 7.97	2.4111	1.4065	2.44	346.56	5.69	Bor
2010 Sep. 12.89	2.4122	1.4107	3.02	345.25	5.51	Bor
2012 Feb. 10.89	2.0794	1.1305	10.12	122.01	–9.75	Bor
2012 Mar. 24.89	2.0497	1.4192	26.18	119.75	–6.73	Bor

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (J2000) (°)	Obs
685 Hermia						
2006 Jul. 18.99	1.7991	0.9945	26.85	349.00	6.59	Bor
2006 Jul. 19.97	1.7993	0.9877	26.53	349.11	6.64	Bor
2006 Aug. 27.82	1.8223	0.8280	8.37	346.71	7.81	SAdS
2006 Aug. 31.98	1.8261	0.8255	6.28	345.83	7.79	Le Cres
2006 Sep. 9.94	1.8368	0.8346	4.58	343.54	7.56	Bor
2006 Sep. 10.95	1.8368	0.8346	4.58	343.54	7.56	SAdS
2006 Sep. 12.91	1.8391	0.8389	5.23	343.09	7.49	Bor
2006 Sep. 13.95	1.8403	0.8414	5.63	342.87	7.45	Bor
2006 Sep. 14.82	1.8414	0.8441	5.01	342.66	7.41	Bor
2006 Sep. 16.91	1.8439	0.8502	7.04	342.24	7.32	Le Cres
2006 Sep. 18.93	1.8464	0.8571	8.06	341.84	7.23	Le Cres
2006 Sep. 18.82	1.8464	0.8571	8.06	341.84	7.23	Bor
2006 Sep. 18.94	1.8464	0.8571	8.06	341.84	7.23	OHP
2006 Sep. 18.82	1.8464	0.8571	8.06	341.84	7.23	OHP
2006 Sep. 19.97	1.8476	0.8608	8.59	341.64	7.18	LE
2006 Sep. 19.95	1.8476	0.8608	8.59	341.64	7.18	OHP
2006 Sep. 19.97	1.8476	0.8608	8.59	341.64	7.18	OHP
2006 Sep. 20.97	1.8489	0.8648	9.12	341.46	7.12	Bed
2006 Sep. 20.91	1.8489	0.8648	9.12	341.46	7.12	OHP
2006 Sep. 20.82	1.8489	0.8648	9.12	341.46	7.12	OHP
2006 Sep. 21.90	1.8502	0.8690	9.66	341.27	7.07	SAdS
2006 Sep. 21.89	1.8502	0.8690	9.66	341.27	7.07	OHP
2006 Sep. 21.89	1.8502	0.8690	9.66	341.27	7.07	OHP
2006 Sep. 22.92	1.8515	0.8734	10.19	341.10	7.02	SAdS
2006 Sep. 25.92	1.8555	0.8877	11.78	340.62	6.84	Le Cres
2006 Sep. 26.93	1.8568	0.8929	12.31	340.47	6.78	Le Cres
2006 Sep. 26.88	1.8569	0.8929	12.31	340.47	6.78	Bor
2006 Sep. 27.94	1.8595	0.9035	13.31	340.21	6.67	SAdS
2006 Sep. 27.94	1.8595	0.9035	13.31	340.21	6.67	Bed
700 Auravictrix						
2003 Mar. 29.05	1.9976	1.0472	12.13	209.42	12.75	Roz
2003 Apr. 2.10	1.9978	1.0323	10.34	208.61	12.86	Roz
2004 Aug. 22.02	2.4388	1.6014	16.51	11.42	–10.15	Roz
2004 Aug. 23.89	2.4400	1.5863	15.84	11.20	–10.26	Roz
2004 Sep. 13.98	2.4484	1.4770	7.79	7.25	–11.24	Bor
2004 Oct. 3.95	2.4547	1.4734	5.84	2.00	–11.35	Bor
2006 Jan. 9.11	2.1277	1.2530	15.83	144.39	6.08	Bor
2006 Jan. 27.16	2.1077	1.1435	7.40	141.13	7.66	Bor
2006 Jan. 29.99	2.1047	1.1333	6.09	140.42	7.88	Roz
2006 Mar. 4.92	2.0704	1.1683	15.21	132.13	9.24	Roz
2007 Aug. 14.00	2.3422	1.3358	3.79	323.19	–8.47	Roz
2008 Nov. 17.99	2.3265	1.4614	14.91	93.12	–3.50	Bor
2009 Jan. 5.78	2.2725	1.3392	10.17	81.51	–1.09	Bor
2009 Jan. 12.84	2.2643	1.3733	13.55	80.11	–0.67	Bor
2011 Oct. 02.03	2.4490	1.6303	16.59	52.03	–8.99	Bor
2011 Nov. 13.00	2.4302	1.4523	4.64	42.95	–8.88	Bor
711 Marmulla						
2009 Sep. 18.90	1.9957	1.0085	7.56	11.19	1.33	Bor
2009 Sep. 25.15	2.0087	1.0103	3.83	9.59	1.80	Bor
2009 Nov. 22.82	2.1405	1.4499	23.11	2.43	4.26	Pic
770 Bali						
2004 Mar. 11.95	2.2880	1.2978	2.76	173.49	6.12	Bor
2004 Mar. 14.96	2.2930	1.3020	2.76	172.65	6.04	Bor
2004 Mar. 30.88	2.3188	1.3641	9.48	168.66	5.46	Bor
2007 Feb. 18.79	2.0552	1.1681	16.16	115.10	7.72	Bor
2007 Mar. 7.90	2.0839	1.3265	22.23	114.63	6.90	Bor
2007 Mar. 10.97	2.0891	1.3592	23.05	114.81	6.75	Bor
2007 Mar. 25.89	2.1149	1.5314	25.97	116.75	6.01	Bor
2008 Jun. 9.74	2.5479	1.5413	3.83	250.23	–3.51	SAAO

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
2008 Jun. 12.77	2.5468	1.5474	5.20	249.47	–3.57	SAAO
2009 Sep. 8.05	1.9463	1.3023	28.17	51.29	–2.43	Bor
2009 Sep. 16.93	1.9367	1.2136	26.33	52.86	–2.21	Bor
2009 Sep. 19.03	1.9345	1.1935	25.80	53.14	–2.15	Bor
2009 Sep. 30.08	1.9239	1.0957	22.37	54.01	–1.77	Bor
2009 Nov. 27.98	1.8897	0.9384	11.26	43.95	1.59	Bor
2010 Mar. 11.82	1.9310	1.9165	29.92	66.94	3.49	Bor
2010 Mar. 13.88	1.9331	1.9395	29.75	67.92	3.49	Pic
2011 Feb. 28.12	2.4632	1.9108	21.85	226.88	1.92	Bor
2011 Mar. 7.11	2.4706	1.8336	20.59	227.28	1.85	Bor
2011 Mar. 25.11	2.4884	1.6608	15.73	226.66	1.59	Bor
800 Kressmannia						
2004 Dec. 13.04	2.3940	1.4140	2.93	78.62	6.59	Roz
2004 Dec. 14.04	2.3940	1.4140	2.93	78.62	6.59	Roz
2006 Mar. 2.02	2.4630	1.5285	9.77	185.97	–3.54	Roz
2006 Apr. 6.89	2.3991	1.4370	8.51	176.62	–4.55	Bor
2006 Apr. 8.81	2.3954	1.4420	9.44	176.15	–4.57	Bor
2007 Oct. 4.12	2.0325	1.1721	19.05	51.56	6.84	Bor
2007 Oct. 9.93	2.0462	1.1471	16.33	50.75	7.13	Kie
2007 Oct. 13.88	2.0556	1.1335	14.34	50.03	7.32	Bor
2007 Nov. 27.78	2.1628	1.2384	12.09	38.74	7.44	Bor
2007 Nov. 28.73	2.1651	1.2460	12.52	38.58	7.41	Bor
2009 Jan. 7.18	2.6208	1.9411	18.13	163.02	0.05	Pic
2009 Feb. 27.02	2.5843	1.5962	1.89	153.74	–1.23	Pic
2009 Apr. 25.98	2.5169	1.9823	22.00	146.24	–2.11	Bor PST
2009 Apr. 28.98	2.5127	2.0155	22.43	146.48	–2.13	Bor PST
2009 Apr. 29.98	2.5113	2.0266	22.57	146.57	–2.14	Bor PST
2010 Aug. 1.08	1.7623	0.8931	24.12	353.92	0.65	Pic
2010 Aug. 22.05	1.7810	0.8079	13.22	352.51	2.27	Bor
2010 Sep. 5.05	1.7976	0.7935	4.47	349.64	3.34	Bor
2010 Oct. 10.82	1.8532	0.9411	17.69	343.36	4.89	Bor
2010 Nov. 14.82	1.9221	1.2863	27.89	347.07	4.86	Bor
2010 Dec. 18.85	1.9980	1.7169	29.49	358.11	4.40	Pic
2012 Feb. 03.00	2.6354	1.6508	1.24	130.65	1.61	Bor
802 Epyaxa						
2006 Feb. 28.01	2.0469	1.0603	3.45	154.38	5.23	Bor
2006 Mar. 05.89	2.0499	1.0716	6.35	152.86	4.88	Bor
2009 Jan. 05.03	2.0296	1.0540	4.82	104.72	9.99	Pic
2009 Jan. 13.99	2.0270	1.0613	7.29	102.32	9.83	Bor
2010 Apr. 27.10	2.5479	1.5413	3.83	250.23	–3.51	SAAO
825 Tanina						
1999 May 17.88	2.0595	1.3194	24.13	180.31	5.18	Bor
1999 May 18.87	2.0594	1.3282	24.39	180.39	5.13	Bor
1999 May 19.88	2.0593	1.3372	24.65	180.47	5.09	Bor
1999 May 20.88	2.0592	1.3462	24.90	180.57	5.05	Bor
1999 May 27.87	2.0586	1.4116	26.44	181.43	4.76	Bor
2002 Feb. 2.14	2.1889	1.2050	1.98	129.93	3.07	Bor
2002 Feb. 3.01	2.1882	1.2048	2.37	129.70	3.10	Bor
2002 Feb. 14.04	2.1789	1.2201	8.32	126.81	3.35	Bor
2002 Feb. 15.04	2.1780	1.2231	8.86	126.57	3.37	Bor
2002 Feb. 18.06	2.1755	1.2334	10.46	125.89	3.42	Bor
2004 Dec. 19.92	2.3199	1.3393	1.22	82.45	–1.69	Bor
2005 Feb. 8.92	2.2822	1.6715	22.88	76.17	–0.21	Bor
2006 Jun. 13.95	2.1039	1.0946	4.24	254.33	2.58	Pic
2007 Oct. 22.05	2.3907	1.4248	7.47	45.74	–5.09	Bor
2007 Oct. 24.09	2.3905	1.4177	6.48	45.23	–5.09	Pic
2007 Nov. 15.95	2.3873	1.4178	6.09	39.17	–4.79	Bor
2007 Nov. 20.83	2.3864	1.4361	8.37	38.01	–4.66	Bor
2007 Nov. 27.92	2.3848	1.4731	11.54	36.56	–4.44	Bor
2007 Dec. 14.86	2.3804	1.6076	17.92	34.50	–3.81	Pic

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
2009 Apr. 19.87	2.0645	1.0944	9.95	190.08	6.36	Bor
2009 Apr. 21.87	2.0642	1.1014	10.98	189.67	6.31	Bor
2009 May 2.90	2.0625	1.1548	16.33	187.92	5.94	Bor
2010 Sep. 17.98	2.3604	1.3638	4.13	2.82	–5.76	Bor
827 Wolfiana						
2009 Nov. 27.94	2.0846	1.1205	7.86	81.41	–6.29	Pic
841 Arabella						
2004 Sep. 19.00	2.3162	1.3123	0.92	358.60	0.40	Kha
2007 Aug. 16.89	2.4054	1.4290	8.30	304.03	–4.34	Roz
2007 Aug. 17.90	2.4052	1.4333	8.76	303.81	–4.31	Roz
864 Aase						
2007 Dec. 14.22	2.3616	1.6818	20.58	139.16	–5.39	Pic
2007 Dec. 15.21	2.3635	1.6729	20.32	139.15	–5.40	Pic
2007 Dec. 19.06	2.3708	1.6392	19.22	139.02	–5.43	Pic
2009 May 19.93	2.3646	1.3635	4.69	232.66	9.01	Bor PST
2009 May 30.04	2.3450	1.3694	8.80	230.01	9.02	Pic
2010 Oct. 16.15	2.0140	1.5260	28.72	98.62	–7.18	Pic
2011 Feb. 8.86	2.2694	1.5487	20.69	85.62	–6.71	Pic
905 Universitas						
2004 Nov. 14.07	1.9960	1.1763	20.84	97.60	5.76	Bor
2004 Nov. 17.00	2.0004	1.1585	19.61	97.41	6.00	Bor
2004 Dec. 11.06	2.0386	1.0730	7.49	93.02	7.68	Bor
2004 Dec. 20.07	2.0536	1.0752	3.97	90.54	8.07	Bor
913 Otilla						
2010 Mar. 9.04	2.2016	1.2775	12.44	195.18	10.03	Bor
2010 Mar. 11.09	2.1975	1.2625	11.57	194.82	10.13	Bor
2010 Mar. 23.06	2.1738	1.1943	6.55	192.12	10.59	Bor
2010 Apr. 7.89	2.1422	1.1588	6.81	187.78	10.68	Bor
2010 Apr. 17.86	2.1223	1.1682	11.39	185.23	10.40	Bor
2010 Apr. 23.87	2.1103	1.1847	14.27	183.95	10.13	Bor
915 Cosette						
2004 Sep. 3.96	2.0503	1.0502	5.07	351.19	–4.24	Bor
2004 Sep. 6.96	2.0460	1.0422	3.48	350.45	–4.08	Bor
2004 Sep. 10.92	2.0404	1.0349	1.96	349.43	–3.86	Bor
2006 Mar. 12.98	2.3951	1.4095	3.98	181.67	1.93	Bor
2008 Dec. 30.95	2.1021	1.2658	18.25	140.94	8.48	Bor
2009 Jan. 5.95	2.1117	1.2306	15.57	140.16	8.63	Bor
2010 Jan. 12.12	2.1212	1.2035	12.71	139.09	8.71	Pic
2010 May 29.90	2.3379	2.4049	24.63	142.62	2.05	Pic
2011 Oct. 2.99	1.9165	1.2510	27.94	73.12	4.96	Bor
2011 Nov. 3.08	1.9188	1.0188	17.18	74.36	7.78	Bor
2011 Nov. 4.13	1.9191	1.0133	16.68	74.24	7.88	Bor
2012 Jan. 30.86	1.9814	1.3628	26.97	64.77	8.01	Bor
2012 Jan. 30.88	1.9814	1.3628	26.97	64.77	8.01	Poz
2012 Mar. 6.85	2.0259	1.7869	29.32	75.48	6.27	Poz
937 Bethgea						
2000 Aug. 28.00	1.7815	0.7948	10.45	351.79	8.21	Bor
2000 Sep. 22.95	1.8169	0.8310	8.71	346.19	7.61	Bor
2000 Sep. 25.87	1.8215	0.8438	10.26	345.68	7.45	Bor
2004 Dec. 15.04	2.5464	1.5976	7.45	102.65	–3.07	Roz
2004 Dec. 15.90	2.5480	1.5951	7.01	102.41	–3.10	Roz
2007 Nov. 21.91	2.2343	1.2466	0.36	58.61	0.58	Kie
2007 Nov. 28.85	2.2516	1.2728	4.16	56.70	0.35	Bor
2007 Dec. 14.08	2.2890	1.3747	11.80	53.29	–0.12	Pic
2007 Dec. 15.07	2.2914	1.3833	12.23	53.13	–0.15	Pic
2007 Dec. 17.09	2.2963	1.4014	13.10	52.81	–0.21	Pic
2009 Mar. 21.94	1.7820	2.7735	2.56	359.38	–4.10	Pic
2010 Aug. 21.91	1.7701	0.8010	14.00	352.48	8.15	Bor
2010 Sep. 3.01	1.7836	0.7857	7.19	350.19	8.26	Bor
2010 Oct. 6.87	1.8347	0.9006	15.91	343.99	6.80	Bor

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
2012 Jan. 31.03	2.7130	1.7306	1.97	129.33	–5.29	Bor
2012 Feb. 26.96	2.7173	1.8468	12.08	123.02	–5.15	Pic
960 Birgit						
2007 Feb. 15.87	2.5692	1.6390	9.28	122.30	–4.19	Pic
2007 Feb. 16.84	2.5700	1.6453	9.70	122.09	–4.19	Pic
2007 Feb. 17.86	2.5709	1.6520	10.12	121.89	–4.18	Pic
967 Helionape						
2007 Oct. 14.99	2.0011	1.0200	7.20	10.41	–9.80	Bor
2007 Oct. 16.86	2.0043	1.0278	8.00	9.98	–9.69	Roz
2007 Oct. 17.99	2.0063	1.0330	8.52	9.72	–9.62	Roz
2009 Mar. 23.96	2.5821	1.8310	17.33	132.41	7.05	Pic
1016 Anitra						
2005 Sep. 8.04	2.0550	1.1165	13.91	14.80	–1.59	Bor
2005 Sep. 9.02	2.0537	1.1103	13.43	14.66	–1.53	Bor
2005 Oct. 7.00	2.0192	1.0221	2.74	8.28	0.40	Bor
2005 Oct. 8.79	2.0172	1.0229	3.85	7.82	0.53	Bor
2005 Oct. 12.87	2.0126	1.0275	6.33	6.79	0.83	Bor
2005 Oct. 18.85	2.0060	1.0414	9.86	5.41	1.25	Bor
1055 Tynka						
2009 Apr. 20.03	2.1756	1.2347	12.35	236.23	9.08	Bor
2009 Apr. 21.04	2.1731	1.2270	11.92	236.06	9.14	Bor PST
2009 Apr. 22.03	2.1707	1.2196	11.49	235.88	9.19	Bor
2009 May 3.03	2.1437	1.1528	6.75	232.50	9.72	Bor
2009 May 12.95	2.1192	1.1171	4.79	230.88	9.99	Bor
2009 May 14.95	2.1144	1.1128	5.11	230.33	10.01	Bor
1056 Azalea						
2004 Jan. 30.09	2.6143	1.7149	10.89	159.09	5.76	Pic
2008 Apr. 25.05	1.8938	1.1330	25.90	50.12	–9.13	Bor
2008 May 8.01	1.8962	1.1199	25.26	50.26	–9.35	Bor
2008 May 9.02	1.8975	1.1132	24.91	50.31	–9.47	Bor
2008 May 11.02	1.8988	1.1070	24.57	50.36	–9.59	Bor
2008 May 12.02	2.0941	1.0964	6.03	241.60	7.66	Bor
2008 May 14.93	2.0881	1.0851	4.81	240.94	7.60	Bor
2008 May 25.94	2.0658	1.0607	4.89	238.08	7.21	Bor
2008 May 28.98	2.0597	1.0590	6.25	237.29	7.05	Bor
2008 May 30.95	2.0557	1.0590	7.23	236.78	6.95	Bor
2011 Mar. 27.98	2.4196	1.4308	4.14	191.17	9.16	Bor
2011 Mar. 30.07	2.4162	1.4254	3.84	190.60	9.19	Bor
2011 Apr. 20.03	2.3801	1.4363	10.65	185.13	9.01	Bor
1060 Magnolia						
2002 Dec. 15.70	2.0110	1.8649	29.11	346.51	2.70	Kha
2005 May 14.90	2.0174	1.0070	1.32	233.39	2.63	Kha
2006 Dec. 14.91	2.5205	1.5400	2.51	82.94	–6.44	Roz
2006 Dec. 20.82	2.5299	1.5551	3.85	81.30	–6.56	Pic
2006 Dec. 22.91	2.5331	1.5629	4.67	80.74	–6.60	Roz
2006 Dec. 23.84	2.5345	1.5668	5.05	80.50	–6.61	Roz
2008 Jan. 21.17	2.5059	1.7786	18.15	188.76	–6.48	Pic
2008 Feb. 6.14	2.5024	1.7538	17.65	188.70	–6.52	Pic
2008 Feb. 8.19	2.3906	1.4358	9.33	176.42	–5.81	Pic
2008 Apr. 7.96	2.3906	1.4358	9.33	176.42	–5.81	Roz
2008 Apr. 30.89	2.3424	1.5489	18.76	172.65	–4.50	Roz
2009 Oct. 12.96	2.1219	1.1697	10.88	43.36	1.67	Pic
2009 Nov. 19.87	2.2116	1.2722	10.49	33.61	–0.48	Pic
2011 Mar. 11.02	2.6300	1.7364	11.64	138.81	–8.52	Pic
2011 Apr. 1.91	2.6067	1.9112	18.50	136.29	–7.43	Pic
1088 Mitaka						
2002 Dec. 10.76	1.8023	1.1953	30.63	9.71	–2.87	Bor
2004 Jan. 22.22	2.5615	2.0000	20.54	187.12	9.13	Pic
2004 Jan. 30.13	2.5697	1.9104	19.02	187.26	9.46	Pic

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
2005 Sep. 5.25	1.9871	1.0164	11.89	293.51	–14.06	PdD
2006 Dec. 23.10	2.3651	1.8214	22.78	159.36	9.86	Roz
2007 Feb. 18.94	2.4683	1.4945	5.06	151.31	12.64	Bor
2007 Feb. 18.91	2.4683	1.4945	5.06	151.32	12.64	Kie
2007 Feb. 23.75	2.4759	1.5029	5.33	149.10	12.6	Kha
2007 Apr. 22.88	2.5544	2.0187	21.59	143.41	9.10	Roz
2008 Jun. 10.77	2.3284	1.3195	3.75	253.19	–4.99	SAAO
2008 Jul. 7.93	2.2709	1.3912	16.48	247.21	–6.07	Pic
2008 Jul. 10.92	2.2643	1.4084	17.66	246.83	–6.14	Pic
2009 Nov. 24.01	2.0883	1.4470	24.95	124.69	7.84	Pic
2009 Nov. 27.15	2.0956	1.4219	24.12	124.86	8.15	Bor
2009 Nov. 28.17	2.0979	1.4139	23.83	124.90	8.25	Bor
2010 Feb. 27.83	2.3039	1.5494	19.55	108.87	10.96	Bor
2010 Mar. 8.81	2.3226	1.6570	21.63	109.06	10.44	Bor
2010 Mar. 14.01	2.3333	1.7233	22.57	109.46	10.14	Pic
2011 Mar. 11.17	2.6014	1.9827	19.71	232.17	3.82	Pic
1117 Reginita						
2002 Dec. 12.84	2.6307	2.8633	20.36	72.26	–3.25	Pic
2004 Jan. 25.18	2.5650	1.7872	16.21	171.17	0.83	Pic
2004 Mar. 19.82	2.4788	1.5204	7.99	159.43	2.43	Roz
2004 Apr. 14.00	2.4311	1.6620	18.45	154.40	2.81	Kha
2005 Sep. 7.00	1.9888	1.0736	16.61	18.55	–4.59	Bor
2005 Sep. 14.11	2.0037	1.0520	12.89	17.32	–5.02	Bor
2005 Oct. 5.01	2.0491	1.0518	2.91	12.13	–5.95	Bor
2006 Dec. 20.98	2.6913	1.9158	15.33	135.18	–2.82	Pic
2006 Dec. 24.02	2.6911	1.8858	14.41	134.87	–2.80	Roz
2007 Feb. 24.00	2.6695	1.7973	12.26	120.0 –	1.6	Kha
2008 Jun. 17.93	1.8369	0.8306	6.50	275.78	8.01	Bor
2008 Jul. 9.96	1.8175	0.8239	10.10	271.15	7.00	Pic
2009 Nov. 20.96	2.5946	1.7793	14.93	101.02	–5.55	Pic
2010 Mar. 14.86	2.6844	2.4280	21.69	87.99	–2.94	Pic
2011 Mar. 9.10	2.3137	1.4265	14.09	202.45	4.63	Bor
2011 Mar. 25.01	2.2787	1.3049	7.12	199.57	5.41	Bor
2011 Apr. 16.03	2.2291	1.2410	5.99	193.74	6.13	Bor
2011 Apr. 21.03	2.2177	1.2439	8.54	192.44	6.20	Bor
2011 Apr. 29.91	2.1973	1.2637	13.01	190.42	6.25	Bor
1130 Skuld						
2004 Jan. 22.05	2.5972	1.6144	1.42	122.76	–3.47	Pic
2006 Dec. 24.82	2.3590	1.3828	3.82	84.11	–2.89	Roz
2007 Jan. 14.83	2.4010	1.5264	13.50	79.63	–2.85	Roz
2007 Jan. 15.87	2.4030	1.5362	13.90	79.48	–2.84	Roz
2008 Feb. 5.15	2.6049	1.9566	18.94	194.73	–1.88	Pic
2009 Sep. 26.08	1.9026	0.9913	17.52	37.94	1.15	Bor
2009 Sep. 29.92	1.9096	0.9777	15.44	37.40	1.06	Bor
2009 Oct. 10.11	1.9287	0.9553	9.44	35.37	0.80	Bor
2009 Nov. 20.85	2.0155	1.1110	14.49	26.18	–0.34	Bor
2009 Dec. 21.76	2.0853	1.4430	24.80	27.24	–0.84	Roz
2011 Feb. 25.88	2.6657	1.6771	1.41	154.59	–3.01	Bor
2011 Feb. 28.90	2.6650	1.6787	3.54	153.78	–2.99	Bor
2011 Mar. 2.82	2.6645	1.6812	3.37	153.26	–2.97	Bor
2011 Apr. 9.95	2.6486	1.9237	17.61	146.64	–2.36	Pic
1133 Lugduna						
2009 Apr. 21.96	2.5413	1.5388	2.12	208.65	4.25	Bor PST
2009 Apr. 25.98	2.5375	1.5392	3.66	207.55	4.12	Bor PST
2009 Apr. 29.98	2.5336	1.5441	5.46	206.49	3.97	Bor PST
2009 May 3.89	2.5297	1.5531	7.24	205.51	3.83	Bor PST
2009 May 12.92	2.5202	1.5884	11.20	203.48	3.45	Bor PST
2009 May 12.92	2.5202	1.5884	11.20	203.48	3.45	Bor PST2
2010 Oct. 7.07	1.8052	0.9052	19.60	50.70	–4.92	Bor
2010 Oct. 11.08	1.8093	0.8879	17.46	50.30	–4.73	Bor
2010 Oct. 18.13	1.8170	0.8642	13.37	49.22	–4.33	Bor

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (J2000) (°)	Obs
1188 Gothlandia						
2006 Jan. 8.89	2.2019	1.2339	6.04	119.40	8.16	Bor
2006 Jan. 10.80	2.2059	1.2339	5.20	118.85	8.15	Bor
2006 Jan. 17.07	2.2189	1.2406	3.56	117.04	8.06	Bor
2008 Oct. 21.14	1.8729	1.0904	24.87	80.12	6.32	Bor
2008 Dec. 9.72	1.9565	0.9810	5.56	71.51	9.02	Bor
2008 Dec. 23.72	1.9835	1.0496	12.27	68.34	8.79	Bor
2009 Jan. 2.94	2.0039	1.1264	14.84	66.99	8.41	Bor
2010 Apr. 7.98	2.5789	1.5807	2.19	203.26	–2.12	Bor
2010 Apr. 17.94	2.5753	1.5768	1.78	200.57	–2.41	Bor
2010 Apr. 24.79	2.5724	1.5903	6.15	198.78	–2.57	SAAO
2011 Aug. 21.05	1.8165	0.9606	23.58	13.51	–2.47	Bor
2011 Sep. 25.06	1.7972	0.7987	4.61	9.92	–0.07	Bor
2011 Oct. 13.81	1.7950	0.8117	8.01	5.65	1.48	Bor
2012 Feb. 01.76	1.8934	1.8309	30.62	30.46	4.11	Poz
1219 Britta						
2003 Nov. 19.91	1.9387	1.0056	13.41	83.92	3.99	Roz
2003 Nov. 20.89	1.9388	1.0006	12.78	83.72	4.07	Roz
2005 Jun. 3.80	2.4869	1.5204	9.08	230.60	–2.11	SAAO
2006 Sep. 22.03	2.0415	1.0683	9.58	18.10	–4.72	Bor
2006 Sep. 25.06	2.0378	1.0554	7.92	17.45	–4.64	Bor
2006 Oct. 17.80	2.0115	1.0282	6.43	11.70	–3.64	Bor
2008 Feb. 7.15	2.3132	1.7840	23.64	207.83	3.58	Pic
2008 Mar. 31.05	2.3763	1.3925	5.49	203.47	3.15	Bor
2008 Apr. 8.99	2.3859	1.3852	1.38	201.09	2.89	Bor
2008 Apr. 24.91	2.4019	1.4258	7.53	196.98	2.34	Bor
2009 Jul. 2.28	2.3034	1.5147	19.79	330.27	–6.72	SPA
2009 Aug. 15.07	2.2437	1.2363	3.58	323.31	–7.90	SAAO
2009 Aug. 15.98	2.2424	1.2351	3.56	323.07	–7.90	SAAO
2010 Dec. 18.07	2.0916	1.6545	27.42	164.12	5.57	Pic
2010 Dec. 20.17	2.0944	1.6331	27.18	164.57	5.65	Pic
2011 Feb. 9.97	2.1677	2.4989	10.97	164.53	7.26	Pic
2011 Feb. 15.09	2.1751	1.2165	8.39	163.33	7.29	Bor
2011 Mar. 1.07	2.1952	1.2088	3.23	159.58	7.15	Bor
1249 Rutherfordia						
2005 Oct. 30.92	2.1369	1.2765	17.25	77.18	2.69	Bor
2008 Sep. 28.91	2.2649	1.2899	7.73	22.11	7.72	Bor
2008 Oct. 7.77	2.2574	1.2652	4.04	22.11	7.66	Bor
2008 Oct. 11.81	2.2539	1.2607	3.35	18.78	7.59	Bor
1376 Michelle						
2004 Apr. 20.90	2.3392	1.3474	5.25	198.76	4.03	Kha
2004 Apr. 21.80	2.3371	1.3475	5.71	198.51	4.05	Kha
2005 Nov. 24.04	2.2563	1.2757	3.89	68.24	–6.22	Pic
2007 Feb. 15.01	2.6509	1.7272	9.38	171.84	–0.11	Pic
2008 Sep. 25.98	1.8388	0.8367	1.44	3.43	–2.63	Bor
2008 Oct. 2.89	1.8513	0.8560	4.72	1.80	–2.95	Bor
2008 Oct. 7.88	1.8606	0.8765	7.76	0.74	–3.15	Bor
2008 Oct. 20.87	1.8864	0.9540	14.94	358.78	–3.51	Bor
1523 Pieksamaki						
2004 Jul. 20.15	2.4445	1.5733	15.34	337.26	–0.86	Roz
2004 Jul. 22.11	2.4450	1.5586	14.62	337.02	–0.80	Roz
2006 Jan. 8.13	2.0878	1.1083	3.30	111.24	6.05	Bor
2006 Jan. 9.90	2.0864	1.1060	2.89	110.79	5.98	Bor
2007 Jun. 18.02	2.3474	1.3879	10.63	290.88	–6.43	Roz
2008 Dec. 7.87	2.2476	1.3472	13.17	45.89	8.61	Pic
2010 Apr. 21.90	2.1549	1.2151	12.65	238.30	–8.96	SAAO
2010 Apr. 25.92	2.1591	1.1994	10.79	237.52	–9.13	SAAO
1562 Gondolatsch						
2006 Mar. 21.91	2.1127	1.2436	17.27	142.28	4.13	Bor
2006 Mar. 23.90	2.1113	1.2566	18.11	142.09	4.17	Bor
2006 Mar. 24.93	2.1105	1.2635	18.53	142.00	4.19	Bor

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
1590 Tsiolkovskaja						
2007 Dec. 18.87	2.4936	1.6329	13.56	50.11	–1.93	Pic
2008 Feb. 9.88	2.5413	2.3002	22.82	52.95	–2.33	Pic
2008 Feb. 10.84	2.5420	2.3139	24.79	53.16	–2.33	Pic
2010 Oct. 18.02	2.2161	1.2395	6.83	9.68	3.95	Bor
1601 Patry						
2009 Jun. 1.07	1.9438	1.0545	19.60	290.66	–2.55	Pic
1619 Ueta						
2009 Apr. 26.05	2.6316	1.6271	1.67	216.74	4.31	Bor
2009 Apr. 28.00	2.6311	1.6263	1.73	216.22	4.24	Roz 2m
2009 Apr. 29.91	2.6306	1.6265	2.20	215.72	4.18	Roz 2m
2010 Sep. 8.06	1.8951	0.9325	12.88	7.40	–11.59	Bor
2010 Oct. 10.95	1.8641	0.8947	10.61	0.15	–10.31	Bor
2010 Oct. 17.88	1.8595	0.9162	14.13	358.93	–9.63	Bor
1667 Pels						
2004 Apr. 2.02	2.0491	1.0850	10.16	212.52	7.41	Bor
2004 Apr. 14.97	2.0267	1.0289	4.16	209.51	7.33	Bor
2004 Apr. 15.97	2.0250	1.0261	3.89	209.24	7.31	Bor
2005 Nov. 23.81	2.4173	1.4417	4.66	50.64	–3.39	Pic
2007 Mar. 11.11	2.2486	1.2621	3.92	166.70	8.23	Bor
2007 Mar. 12.13	2.2468	1.2609	4.18	166.41	8.24	Bor
2007 Mar. 13.05	2.2453	1.2602	4.46	166.16	8.24	Bor
2008 Oct. 21.03	2.2326	1.2486	5.14	18.73	–7.03	Bor
2008 Oct. 24.94	2.2395	1.2660	6.89	17.75	6.87	Bor
2009 Jan. 10.79	2.3649	2.1546	25.11	20.56	–2.97	Pic
2010 Apr. 25.77	2.3183	1.9949	25.59	130.94	5.20	SAAO
2011 Dec. 27.85	2.1945	2.2291	25.67	350.89	–4.10	NOT
1675 Simonida						
2004 Jan. 24.86	1.9593	1.6278	30.08	38.15	5.05	Pic
2005 Apr. 12.93	2.4036	1.4289	7.29	220.79	–0.64	Roz
2005 Apr. 13.97	2.4047	1.4259	6.78	220.54	–0.69	Roz
2007 Dec. 19.21	2.0827	1.7658	28.12	172.73	7.33	Pic
2008 Jan. 21.13	2.1275	1.4410	23.24	178.59	8.25	Pic
2008 Feb. 15.15	2.1632	1.2627	14.10	177.03	8.56	Bor
2008 Feb. 17.01	2.1659	1.2538	13.24	176.70	8.55	Bor
2008 Mar. 28.83	2.2253	1.2714	10.05	166.56	6.70	Bor
2008 Apr. 20.97	2.2586	1.4560	19.19	163.77	4.88	Bor
2009 Jun. 29.08	2.4691	1.4987	9.04	297.14	–11.02	SPA
2009 Jun. 30.31	2.4682	1.4928	8.57	296.86	–11.08	SPA
2009 Aug. 14.98	2.4306	1.5462	14.62	286.35	–10.72	SAAO
2010 Nov. 15.05	1.9571	1.2735	26.19	112.99	8.73	Bor
2010 Nov. 30.85	1.9608	1.1452	21.33	113.92	10.37	Bor
2011 Jan. 10.81	1.9812	1.1686	6.71	106.45	13.11	Bor
2011 Feb. 8.04	2.0034	1.1408	18.20	101.10	11.99	Bor
2011 Feb. 20.97	2.0155	1.2492	22.71	100.91	10.99	Bor
2011 Feb. 22.83	2.0174	1.2666	23.24	101.01	10.84	Bor
1682 Karel						
2008 Jan. 13.20	2.6277	1.7619	12.46	147.53	1.14	Pic
2008 Jan. 15.14	2.6292	1.7483	11.72	147.19	1.10	Pic
2008 Jan. 19.07	2.6322	1.7233	10.15	146.44	1.03	Pic
2008 Jan. 20.06	2.6330	1.7175	9.74	146.24	1.02	Pic
2008 Feb. 13.03	2.6425	1.6649	3.43	142.85	0.73	Pic
2009 Jul. 1.05	2.0349	1.0938	14.80	249.25	–6.64	SPA
2010 Dec. 19.06	2.4245	1.4898	9.29	110.00	4.65	Pic
1793 Zoya						
2011 Feb. 23.07	2.0354	1.0481	2.49	158.40	–2.75	Bor
2011 Feb. 23.98	2.0348	1.0467	2.04	158.17	–2.75	Bor
2017 Wesson						
2004 Jun. 19.95	1.9534	1.0002	14.47	241.72	9.47	Roz
2004 Jun. 23.92	1.9467	1.0131	16.45	241.12	9.34	Roz

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
2005 Nov. 22.20	2.4837	1.5972	12.56	92.32	–7.57	Pic
2005 Nov. 24.21	2.4870	1.5869	11.73	91.93	–7.63	Pic
2006 Jan. 21.89	2.5695	1.7648	15.28	78.63	–6.92	Pic
2007 Feb. 16.05	2.4770	1.6909	16.82	193.46	0.63	Pic
2007 Mar. 22.04	2.4183	1.4261	2.80	187.54	1.90	Roz
2007 Mar. 24.07	2.4146	1.4195	1.83	187.00	1.98	Roz
2007 Mar. 24.95	2.4130	1.4170	1.44	186.76	2.01	Roz
2008 Nov. 3.01	2.1757	1.1898	3.93	35.17	–6.44	Roz
2009 Jan. 3.84	2.3071	1.8042	23.90	31.77	–5.60	Pic
2009 Jan. 11.87	2.3235	1.9182	24.50	33.33	–5.40	Pic
2009 Jan. 30.84	2.3614	2.1953	24.62	38.24	–4.96	Pic
2010 Apr. 30.8	2.5694	2.2137	22.79	139.18	–0.94	SAAO
2011 Jul. 12.08	1.8380	0.8672	13.75	313.64	8.04	Pic
2011 Aug. 26.85	1.8419	0.8893	15.15	305.26	5.25	Bor
2011 Sep. 20.81	1.8580	1.0623	25.18	305.61	3.02	Bor
2036 Sheragul						
2007 Oct. 22.12	2.4337	1.6569	17.84	76.56	5.57	Pic
2156 Kate						
2001 Oct. 19.88	1.7921	0.7965	1.22	25.31	1.81	Bor
2001 Nov. 5.90	1.7978	0.8397	11.87	21.85	3.22	Bor
2001 Nov. 10.75	1.8004	0.8628	14.67	21.20	3.54	Bor
2003 Mar. 26.95	2.6684	1.6710	0.68	185.38	1.75	Roz
2006 Jan. 25.12	2.4059	1.5083	12.20	155.35	6.93	Pic
2006 Jan. 29.02	2.4137	1.4915	10.47	154.52	6.94	Roz 2m
2006 Jan. 31.94	2.4195	1.4814	9.14	153.84	6.94	Roz 2m
2008 Dec. 24.03	2.0358	1.0621	5.41	97.65	10.06	Bor
2008 Dec. 31.14	2.0520	1.0780	5.20	95.65	10.08	Bor
2009 Jan. 14.12	2.0842	1.1461	10.96	92.27	9.73	Bor
2009 Feb. 3.81	2.1327	1.3251	19.35	89.95	8.63	Pic
2010 Apr. 17.97	2.6855	1.6839	1.89	212.49	–1.98	SAAO
2010 Apr. 20.88	2.6844	1.6801	0.87	211.72	–2.07	SAAO
2010 Apr. 22.78	2.6836	1.6789	0.93	211.22	–2.12	SAAO
2010 Apr. 23.85	2.6832	1.6787	1.27	210.94	–2.16	SAAO
2011 Sep. 29.85	1.8037	0.8033	2.49	2.71	–2.64	Bor
2011 Sep. 30.89	1.8030	0.8036	3.06	2.47	–2.54	Bor
2283 Bunke						
2004 Sep. 7.90	2.4379	1.4376	3.67	352.00	5.24	Kha
2009 Jan. 4.83	2.2816	1.4677	17.33	61.66	–9.25	Pic
2460 Mitlincoln						
2004 Nov. 3.90	2.1603	1.1790	5.17	51.81	–5.33	Kha
2004 Nov. 14.83	2.1472	1.1618	3.14	48.91	–5.63	Pic
2007 Oct. 17.84	2.3573	1.4944	15.26	345.57	–0.47	Roz
2007 Nov. 2.92	2.3391	1.6290	20.44	344.66	–0.83	Pic
2009 Mar. 21.85	2.0912	1.1127	7.05	166.41	–0.35	Bor
2009 Mar. 27.98	2.0975	1.1397	10.41	165.10	–0.09	Roz
2009 Apr. 19.92	2.1226	1.3081	20.32	162.76	0.72	Bor PST
2009 Apr. 20.88	2.1237	1.3171	20.64	162.76	0.75	Bor PST
2009 Apr. 27.91	2.1318	1.3862	22.69	162.98	0.94	Pic
2009 Jun. 2.93	2.1753	1.8045	27.56	169.52	1.60	Roz
2961 Katsurahama						
2006 Dec. 25.05	1.9773	1.0287	10.46	72.44	–5.78	Roz
2008 May 1.98	2.5691	1.5616	0.86	224.12	0.25	Roz
2009 Sep. 20.80	2.1069	1.1180	6.51	345.82	6.55	Bor
2009 Sep. 24.89	2.1010	1.1248	8.58	344.85	6.36	Bor
3953 Perth						
2008 Feb. 4.92	2.4814	1.4964	1.24	138.37	1.14	Pic
2009 May 25.99	2.4685	1.4704	5.22	234.73	7.84	Roz 2m
2009 May 27.94	2.4652	1.4716	5.99	234.23	7.80	Roz 2m
2011 Feb. 8.88	2.2003	1.5778	23.70	76.09	3.40	Pic

Table A.1. continued.

Date (UT)	r (AU)	Δ (AU)	Phase angle (°)	λ (J2000) (°)	β (°)	Obs
3986 Rozhkovskij						
2005 Aug. 10.95	2.3769	1.3752	4.91	328.44	5.77	Roz
2005 Sep. 6.91	2.3401	1.3813	9.90	321.68	6.38	Roz
4150 Starr						
2004 Aug. 20.96	1.8637	0.8529	1.91	329.97	–3.06	Roz
2011 Oct. 17.98	2.0875	1.1374	11.22	47.60	–5.86	Bor
2011 Nov. 6.01	2.1238	1.1352	2.76	42.64	–5.90	Bor
2011 Nov. 21.02	2.1529	1.1984	9.11	38.90	–5.56	NOT
2011 Nov. 27.02	2.1646	1.2391	12.00	38.75	–5.36	NOT

Notes. Observatory codes: Bed – Bedoin Observatory, France; Bor – Borowiec, Poland; HH – Hunters Hill Observatory, Australia; Kha – Kharkov, Ukraine; Kie – Kielce Observatory, Poland; Le Cres – Le Cres Observatory, France; LE – Les Engarouines, France; NOT – Nordic Optical Telescope, La Palma, Spain; OHP – Observatoire de Haute Provence, France; PdD – Pico dos Dias, Brazil; Pic – Pic du Midi, France; Poz – Poznan Observatory, Poland; Roz – NAO Rozhen, Bulgaria; SAAO, Republic of South Africa; SAdS – Stazzione Astronomica di Sozzago, Italy; SPA – San Pedro de Atacama, Chile.