Supplementary Material

Binary Asteroid Population. 2. Anisotropic distribution of orbit poles of small, inner main-belt binaries

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Photometric observations of binary asteroids

We carried out photometric observations using our standard asteroid lightcurve photometry techniques. The data were corrected for light-travel time and standard calibration with dark and flatfield frames was applied to all images. We analysed the observations using our methods described in Pravec et al. (2006).

The individual observing sessions in the Supplementary Information are identified with the date given to the nearest 10th of a day to the midtime of the session's observational interval. The times of the beginning and end of the observing interval in each apparition in Section 5 are actual UTC of the first and last observations in the apparition, rounded to the nearest 10th of a day. All dates and times in Suppl. Fig. 1 to Fig. 38 are asterocentric JD (UTC), i.e., they were light-time corrected. In Suppl. Table 1, there are listed the participating observatories, instruments and observers. We give references and descriptions of observational procedures on the individual observatories in following.

Andrushivka – Observational and reduction procedure at Andrushivka Astronomical Observatory see in Ivashchenko et al. (2003).

Badlands – Observations were made with a 0.66-m Newtonian reflector at f/4.8, with Apogee AP8, back-illuminated, 1024×1024 pixels CCD and clear IR-blocking filter to eliminate fringing. This setup is resulting in a 1.56 arcsec/pixel scale and $27' \times 27'$ FOV. Image calibration was usually done on the fly by using ACP observatory control software in conjunction with MaxIm DL. Master flats were prepared by median-combining 5–6 subframes that had been exposed to about 50% well depth. Most of the flats made use of a full-aperture electro-luminescent screen. Some may have been prepared by using the natural twilight sky in conjunction with a full aperture diffuser. Master darks were prepared by median-combining 3 subframes taken at the proper camera operating temp for each observing run.

Bellatrix, Campo Catino, La Silla – Observational and reduction procedures for observations by Gianluca Masi on the three stations were analogous to

those he used for observations in Pravec et al. (2006). Technical information on the Danish 1.54-m telescope on La Silla is available at
`http://www.eso.org/lasilla/telescopes/d1p5/`.

Carbuncle Hill – Observational and reduction procedure at Carbuncle Hill Observatory is described in Warner and Pray (2009).

Cerro Tololo Inter-American Observatory (CTIO) – General information about the 0.9-m system is available at
`http://www.ctio.noao.edu/telescopes/36/0-9m.html`. The telescope was operated in service mode and we used the full chip setting with the FOV $13' \times 13'$, the readout noise ~ 5 ADU $= 3e^-$ and V filter. Integration times were mostly 120 s. *MaxImDL* was used to process and reduce the observations.

Elginfield – The telescope is a 1.22-m f/8.3 using a FLI 1024×1024 CCD camera with a $30' \times 30'$ field of view in unbinned mode. All measurements were made in sidereal tracking mode with exposures short enough to avoid smearing, typically 60–120 sec. We use MAXIM DL as the main software reduction tool. All measurements were differential aperture photometry and these were done (typically) through a custom-designed light pollution filter which fairly approximated the Johnson-Cousins R-band response. We applied flats and darks as per standard photometric reduction techniques to all measurements.

GMARS – Observations were made with a 0.35-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E CCD camera. All images were unguided and unbinned with no filter. Measurements were made using MPO Canopus, which employs differential aperture photometry to produce the raw data. Period analysis was done using Canopus, which incorporates the Fourier analysis algorithm (FALC) developed by Harris et al. (1989). From 2008 we used improved reduction technique when night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors.

Hunters Hill – Observations were collected using a Meade 0.35-m Schmidt-Cassegrain telescope with Meade f/3.3 Focal Reducer and an SBIG ST-8e CCD Bin 1×1 with a clear filter resulting in a 1.32 arcsec/pixel scale. Due to vignetting, each frame is cropped prior to download to a central region of 1148×768 px. Multiple targets are observed during each observing window using an automated system controlled by ACP5 and an observing script. At the end of each observing session, images are downloaded from the observatory PC and manually reduced using MPO Canopus v10 aperture photometry. Interfering background stars are removed by MPO Canopus' StarBGone routine but if this routine proves ineffective, the affected image/data point is discarded. Each image is manually checked and poor images (excess trailing, internal reflections, cloud or other defects) are discarded. Calibration is undertaken using library darks and flats.

Kharkiv – CCD photometry of the small binary asteroids conducted at the 0.7-m reflector of the Institute of Astronomy of Kharkiv Karazin National University using the SBIG ST-6UV CCD and high-sensitivity CCD camera

IMG 47-10 (1024×1024 pixels). The camera is equipped with 3-lens focal corrector and installed in Newtonian focus (f/4). The method of observations and data reduction were described in Krugly et al. (2002). Reduction of the observations was performed by using the synthetic aperture photometry package (ASTPHOT) developed at DLR and described in Mottola et al. (1995).

Las Campanas – General information about the Swope 1-m telescope is available at `http://www.lco.cl/telescopes-information/henrietta-swope`. At the Cassegrain F/7 focus of the telescope we used the SITe#3 2K $\times$ 3.6K pixel camera giving a field of $15.1' \times 26.5'$ with a pixel scale 0.43"/pix. We used an R band filter and no binning.

Leura – Observational and reduction procedures in Leura is described in Oey (2010).

Lick – Observations were collected using the Lick Observatory 1m-Nickel telescope and its Direct Imaging Camera at the f/17 Cassegrain focus in R band. The detector is a thinned, Loral, 2048×2048 CCD with 15-micron pixels, corresponding to 0.184 arcsec/pixel, so a FOV of 6.3×6.3 arcmin. The observations were remotely conducted from a control room located at the Department of Astronomy of the University of California at Berkeley. The relative photometry measurements were made using an automatic software developed in Python 2.5/2.6. It detects and reduces the asteroid and three selected nearby bright comparison stars on each processed frame (after dark subtraction, badpixel removal, and flat-field correction). The flux is estimated with an aperture photometry technique using a Gaussian fit function. A reducer checks the frames for a possible contamination of the images of the asteroid and the comparison stars by a remnant bad pixel, cosmic rays, or a background star and such affected data points are discarded.

Linhaceira – All observations were done with the SC LX200 10" scope. The data for (2044) Wirt were taken with StarlightXpress MX916 CCD, 210-s exposures, no filter and telescope at f/6.9. The data for (2754) Efimov were taken with Audine CCD, 300-s exposures, clear filter and telescope at f/6.7. After images pre-processing (bias, dark, flatfield and bad pixel removal correction), data reduction was done with Canopus software with aperture photometry with 4 to 5 comparison stars at field, checking also possible foreground fainter stars interference.

Modra – Observational system, data analysis and reduction process are described in Galád et al. (2007) and recently they made use of tools provided by Astrometry.net (Lang et al. 2010).

Ondřejov – Observational system, data analysis and reduction process are described in Pravec et al. (2006).

Palmer Divide Observatory (PDO) – Observational system, data analysis and reduction process are described in Warner (2010).

PROMPT – The University of North Carolina at Chapel Hill's PROMPT observatory (Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes) is on Cerro Tololo. PROMPT consists of six 0.41-m outfitted with Alta U47+ cameras by Apogee, which make use of E2V CCDs. The field of view is $10' \times 10'$ with 0.59 arcsec/pixel. All raw image frames were processed (master dark, master flat, bad pixel correction) using the software package MIRA. Aperture photometry was then performed on the asteroid and three comparison stars. A master image frame was created to identify any faint stars in the path of the asteroid. Data from images with background contamination stars in the asteroid's path were then eliminated.

Shed of Science – We used a 0.35-m Schmidt Cassegrain (SCT) with an SBIG ST10XE CCD camera working at a scale of 0.94 arcsec/pixel. Exposures were made through a Celestron UHC LPR filter. All images are dark and flat field corrected. We used MPO Canopus to perform differential photometry on the reduced images. Additional information regarding reduction process can be found in Durkee and Brinsfield (2011).

Simeiz – The observations of the asteroids were carried with 1-m Ritchey-Chrétien telescope at Simeiz Department of the Crimean Astrophysical Observatory using cameras SBIG ST-6, Apogee Alta, FLI PL09000, and FLI IMG1001E. The observations were made in Johnson-Cousins photometric system. Standard procedure of the image reduction included dark removing and flat fielding. The aperture photometry have been done with AstPhot package described in Mottola et al. (1995). The differential lightcurves were calculated with respect to the comparison star ensemble by method described in Ericson et al. (2000) and Krugly (2004).

Skalnaté Pleso – Observational and reduction procedure at Skalnaté Pleso Observatory is described in Husárik and Kušnirák (2008).

Sonoita Research Observatory (SRO) – The Sonoita Research Observatory observations were collected with two different optical assemblies. All excepting the 2010 images of (3309) Brorfelde were made with a 0.36-m Celestron Schmidt Cassegrain optical tube assembly operating at f/11. Unfiltered images were taken with an SBIG STL-1001E yielding a 1.27 arcsecond/pixel image scale. The 2010 images of (3309) Borfelde were taken with a 0.5-m folded Newtonian operating at f/4 and an SBIG STL-6303E with an image scale of 0.92 arcseconds/pixel. Both optical assemblies were mounted on a Software Bisque Paramount ME and tracking was sidereal on a fixed nightly field rather than tracking on the asteroid. Integration times were typically 300 seconds. The images from both optical assemblies were dark subtracted and flat fielded, then reduced using MIRA for ensemble differential photometry using well placed comparison stars near the path of the asteroid through the frame. The images were examined for interfering stars and those images were discarded.

Via Capote – Observations were made using a Meade LX-200 0.36-m SCT at the f/10 prime focus. The CCD imager was an Alta U6 featuring a 1024×1024 array of 24-micron pixels. All observations were made unfiltered at 1x binning yielding an image scale of 1.44 arcseconds. All images were dark and flat field calibrated and reductions were performed with Canopus.

Suppl. Table 1
Observatories, Instruments and Observers/Reducers

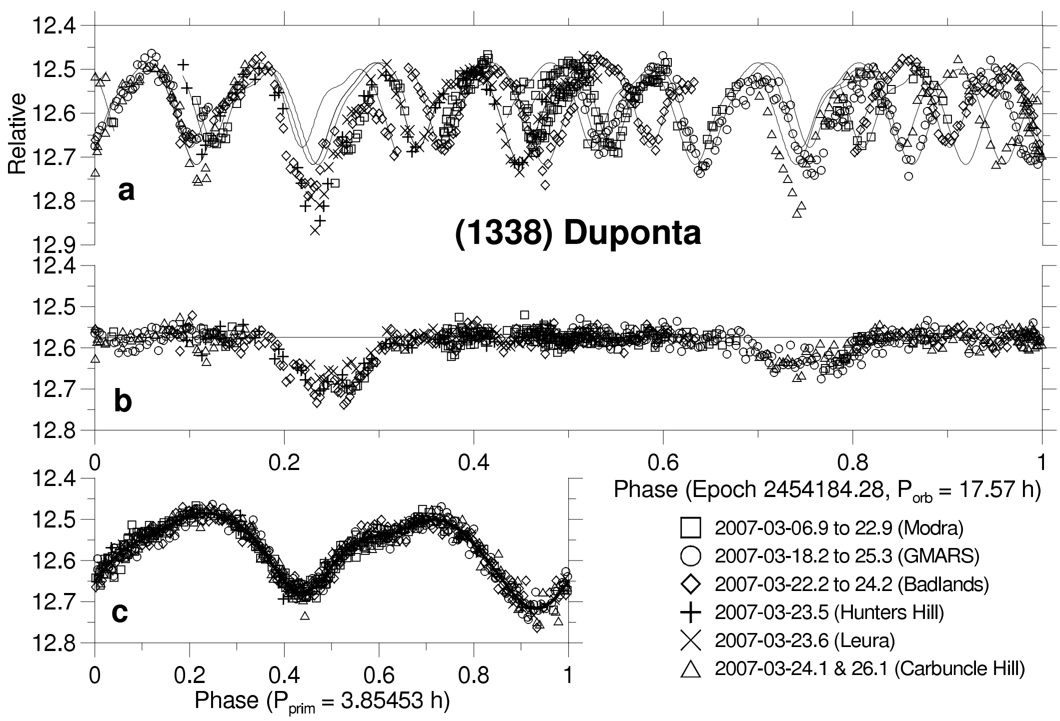
Observatory	**Telescope**	**Diameter (m)**	**Observers/Reducers**
Andrushivka		0.60	Gerashchenko
Badlands		0.66	Dyvig, Reddy
Bellatrix		0.28	Masi
Campo Catino		0.81	Masi, Mallia
Carbuncle Hill		0.35, 0.50	Pray
CTIO		0.90	Longa-Peña, Vaduvescu, Galád
Elginfield		1.22	Brown, Krzeminski
GMARS		0.35	Stephens
Hunters Hill		0.35	Higgins
Kharkiv		0.70	Chiorny, Krugly, Shevchenko, Slyusarev
La Silla	Danish	1.54	Masi
Las Campanas	Swope	1.0	Galád, Vaduvescu, Tudorica
Leura		0.25, 0.35	Oey
Lick	Nickel	1.0	Marchis
Linhaceira		0.25	Gonçalves
Modra		0.60	Galád, Világi, Gajdoš, Kornoš
Ondřejov		0.65	Kušnirák, Hornoch
PDO		0.35, 0.50	Warner
PROMPT	Prompt5	0.41	Pollock
Shed of Science		0.35	Durkee
Simeiz		1.0	Gaftonyuk, Krugly
Skalnaté Pleso		0.61	Husárik, Pikler, Červák
SRO		0.36, 0.5	Cooney, Gross, Terrell
Via Capote		0.36	Brinsfield

(1338) Duponta

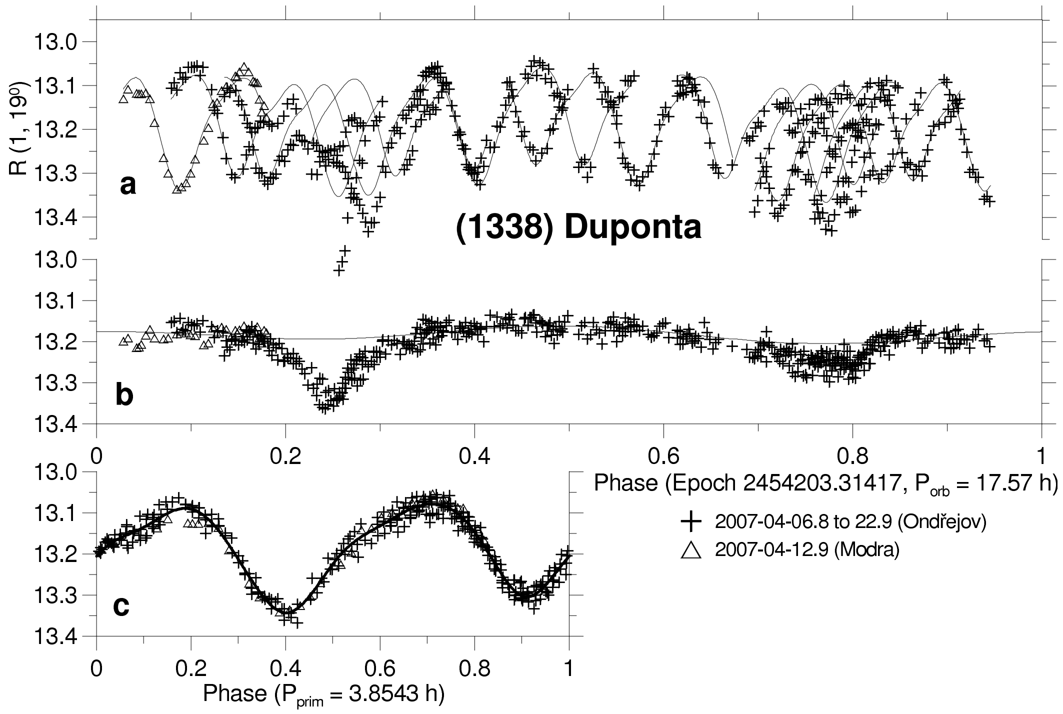
We observed this binary in two apparitions of 2007 and 2010. Our discovery announcement was Gajdoš et al. (2007). In the discovery apparition, the observations were taken from 2007-03-06.9 to 04-22.9, split into two shorter intervals. Data from the first interval, 11 nights from 03-06.9 to 26.1, are shown in Suppl. Fig. 1, they were taken from Modra, GMARS, Badlands, Hunters Hill, Leura and Carbuncle Hill. The data are relative, i.e., they were not calibrated in a standard photometric system. Our analysis of these observations provided an estimate of the primary period of $P_1 = 3.85453 \pm 0.00009$ h, with the estimated synodic-sidereal period difference $\Delta P_{\mathrm{syn-sid}} = 0.00008$ h. An amplitude of the primary rotational lightcurve component was $A_1 = 0.23$ mag.

In Suppl. Fig. 2, there are shown data taken in the second interval of the 2007 apparition, 10 nights from 04-06.8 to 22.9, taken from Ondřejov and Modra. These data provided an estimate of the primary period of $P_1 = 3.8543 \pm 0.0002$ h with amplitude $A_1 = 0.26$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. The calibrated data revealed that there was present also a second rotation lightcurve component, consistent with being due to synchronous rotation of elongated secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.04$ mag (see Suppl. Fig. 2b).

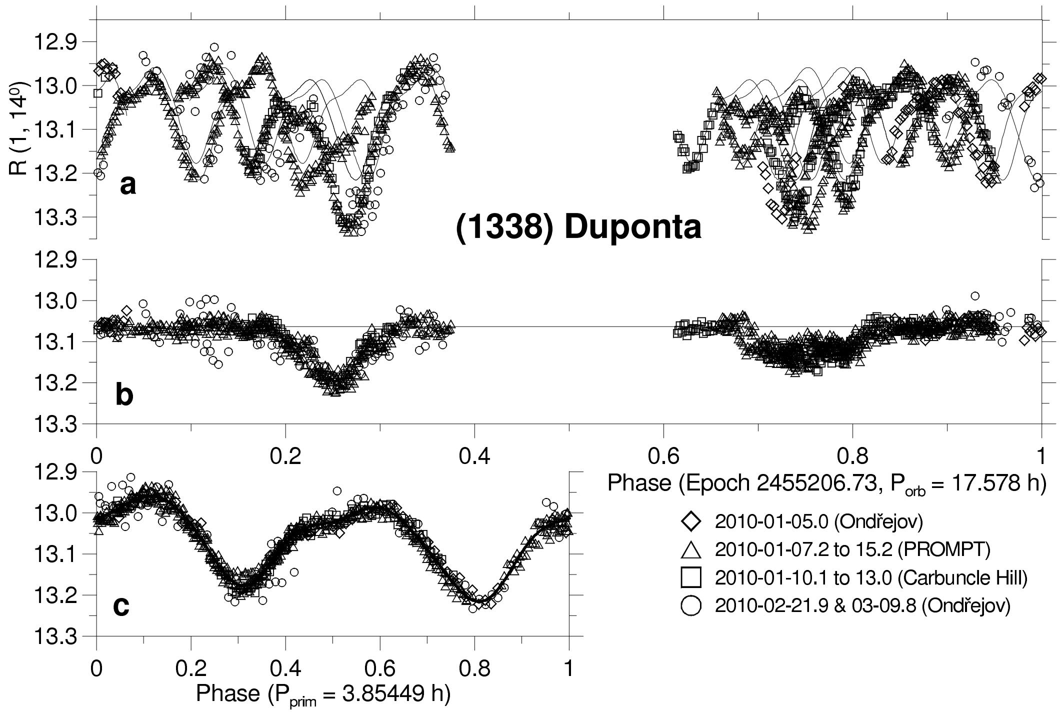
In the return apparition, we observed the binary from PROMPT, Ondřejov, and Carbuncle Hill on 9 nights from 2010-01-05.0 to 03-09.8. Suppl. Fig. 3 shows 1266 observations used in our solution. We estimated the primary period $P_1 = 3.85449 \pm 0.00003$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00038$ h) and $A_1 = 0.26$ mag. The flat bottom of the secondary event indicates that the mutual event was total. From the depth of the total secondary events, we estimated the secondary-to-primary mean diameter ratio $D_2/D_1 = 0.24 \pm 0.02$. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 12.30 \pm 0.04$ and slope parameter $G = 0.19 \pm 0.03$.



Suppl. Fig. 1. Lightcurve data of (1338) Duponta from March 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



Suppl. Fig. 2. Lightcurve data of (1338) Duponta from April 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and rotational lightcurve of secondary component. (c) The primary lightcurve component.



Suppl. Fig. 3. Lightcurve data of (1338) Duponta from 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

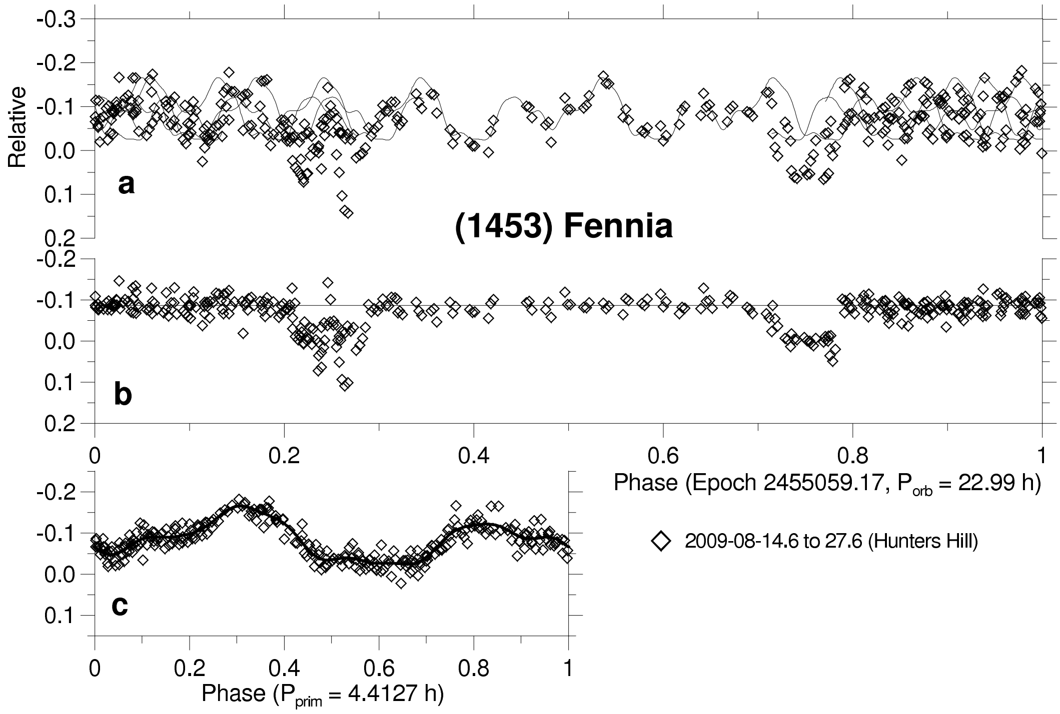
(1453) Fennia

We observed this binary in three apparitions of 2007, 2009 and 2011. Our discovery announcement was Warner et al. (2007). Data from the discovery apparition, taken on 18 nights from 2007-11-04.4 to 12-02.2, were already published in Warner et al. (2008). Our updated solution for the primary period and amplitude is $P_1 = 4.41224 \pm 0.00006$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00034$ h), $A_1 = 0.18$ mag.

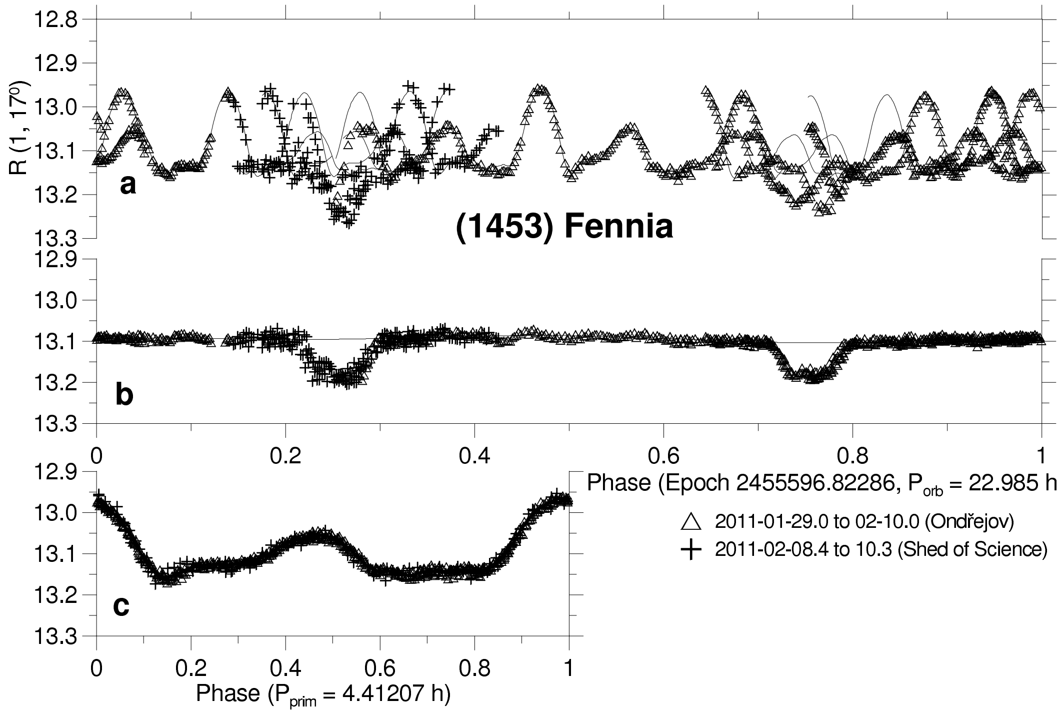
In the second apparition we observed the binary from Hunters Hill on 6 nights from 2009-08-14.6 to 27.6, the data were relative and they are shown in Suppl. Fig. 4. Our analysis of these data provided an estimate of the primary rotation period $P_1 = 4.4127 \pm 0.0004$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0006$ h) and $A_1 = 0.14$ mag.

Data from the third apparition are the most accurate and abundant data we got for the binary. They were taken from Ondřejov, Shed of Science, Modra and PROMPT on 22 nights from 2011-01-29.0 to 04-29.9. The best data were taken during 01-29.0 to 02-10.3, from Ondřejov and Shed of Science and they are shown in Suppl. Fig. 5. These data provided an estimate of the primary period of $P_1 = 4.41207 \pm 0.00006$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00026$ h) and amplitude $A_1 = 0.19$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01-0.02 mag. The calibrated data revealed that there was present also a second rotation lightcurve component, consistent with being due to synchronous rotation of the secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.02$ mag (see Suppl. Fig. 5b). From these calibrated data we derived the asteroid's absolute magnitude $H_R = 12.38 \pm 0.05$ and slope parameter $G = 0.33 \pm 0.05$.

More observations were taken later during the apparition. These data are of similar quality as but with less abundant coverage than the data shown in Suppl. Fig. 5. A purpose of the extended observations was monitoring evolution of the mutual events for further modeling of the binary. The events were observed throughout the apparition and the observations showing their evolving shapes were used in precise modeling of the system.



Suppl. Fig. 4. Lightcurve data of (1453) Fennia from 2009. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



Suppl. Fig. 5. Lightcurve data of (1453) Fennia from 2011. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and rotational lightcurve of secondary component. (c) The primary lightcurve component.

(1830) Pogson

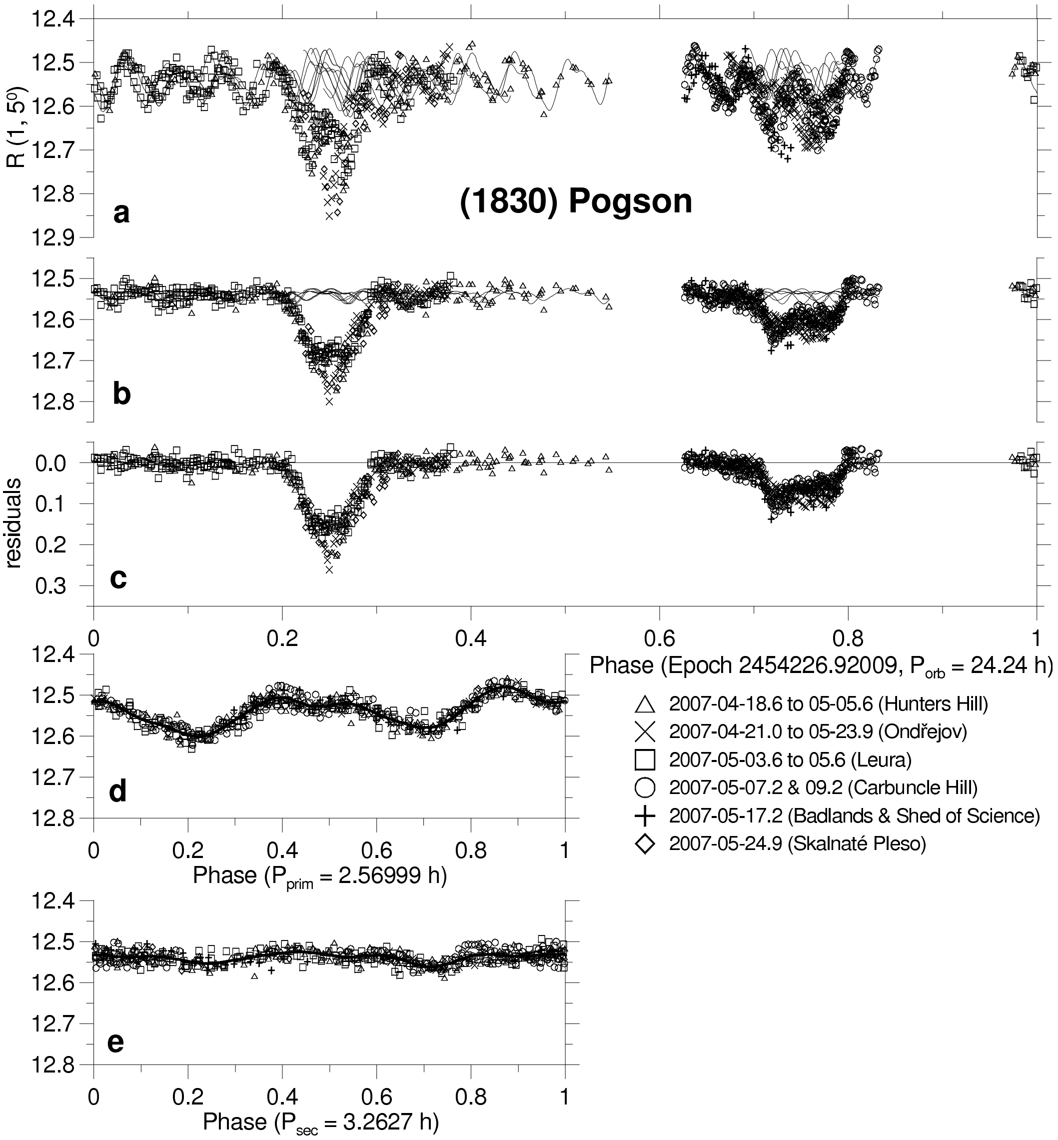
We observed this binary in three apparitions of 2007, 2008 and 2010. Our discovery announcement was Higgins et al. (2007a). In the discovery apparition, the observations were taken from Hunters Hill, Ondřejov, Leura, Carbuncle Hill, Badlands, Shed of Science and Skalnaté Pleso Observatory on 19 nights from 2007-04-18.6 to 05-24.9. The data are shown in Suppl. Fig. 6. We estimated the primary period $P_1 = 2.56999 \pm 0.00004$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00003$ h) and $A_1 = 0.12$ mag. There appeared also a second rotational lightcurve component with period $P_2 = 3.2627 \pm 0.0002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00004$ h) and amplitude $A_2 = 0.04$ mag, shown in Suppl. Fig. 6e. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. Assuming the slope parameter $G = 0.29 \pm 0.05$ estimated from observations taken in 2010 (see below), we derived the asteroid's absolute magnitude $H_R = 12.17 \pm 0.03$.

In the return apparition, the observations were taken from 2008-09-03.0 to 11-06.8, split into two sub-intervals. The observations in the first interval were taken from Skalnaté Pleso, GMARS, La Silla and Lick observatory on 12 nights from 09-03.0 to 10-01.5. Our analysis of these observations provided an estimate of the primary period of $P_1 = 2.57013 \pm 0.00003$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00003$ h) and amplitude $A_1 = 0.10$ mag. For the second rotational lightcurve component we derived $P_2 = 3.2634 \pm 0.0002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00004$ h) and amplitude $A_2 = 0.03$ mag. The observations in the latter interval were taken from Hunters Hill, Ondřejov and Kharkiv on 8 nights to 11-06.8 and are shown in Suppl. Fig. 7. From these data we estimated the primary period $P_1 = 2.56990 \pm 0.00005$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00005$ h) and amplitude $A_1 = 0.10$ mag. The data again show a presence of the second rotational component, $P_2 = 3.2622 \pm 0.0003$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00008$ h) and $A_2 = 0.03$ mag, and it is shown in Suppl. Fig. 7e. The Ondřejov session of 10-05.0 was absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag and it provided an estimate of the asteroid's absolute magnitude of $H_R = 12.16 \pm 0.02$, assuming the slope parameter $G = 0.29 \pm 0.05$ derived from observations taken in 2010.

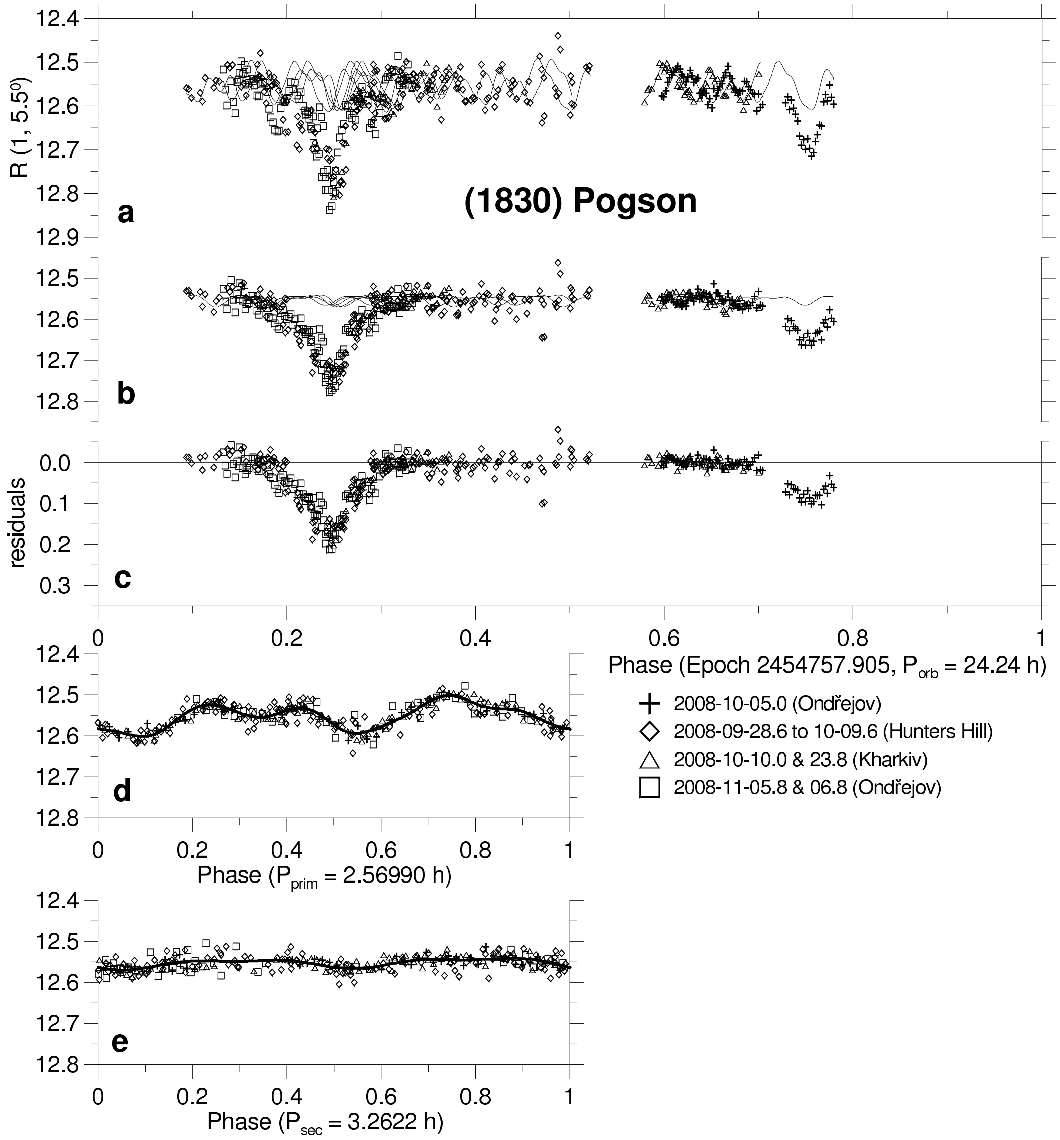
We obtained the best data in the third apparition of 2010. We observed this binary from Leura, PROMPT, Ondřejov, Modra, Kharkiv and Shed of Science on 17 nights from 2010-02-20.7 to 04-08.6. The data are shown in Suppl. Fig. 8. We estimated the primary period $P_1 = 2.57010 \pm 0.00002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00004$ h) and $A_1 = 0.12$ mag. The second rotational lightcurve component was best recognizable in these data, and we estimated its period $P_2 = 3.2621 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00007$ h) and amplitude $A_2 = 0.03$ mag (see Suppl. Fig. 8e). The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to a level of 0.01-0.02 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 12.18 \pm 0.03$ and slope parameter $G = 0.29 \pm 0.05$.

Both rotational components were present at all orbital phases including mutual events, with unchanged shape in the event. The fact that the second rotational component did not disappear in mutual events indicates that it is not a rotation of the secondary. We consider that it may rather belong to a third body in the system. This proposed explanation will have to be confirmed and a size and distance of the third body will have to be estimated with future observations.

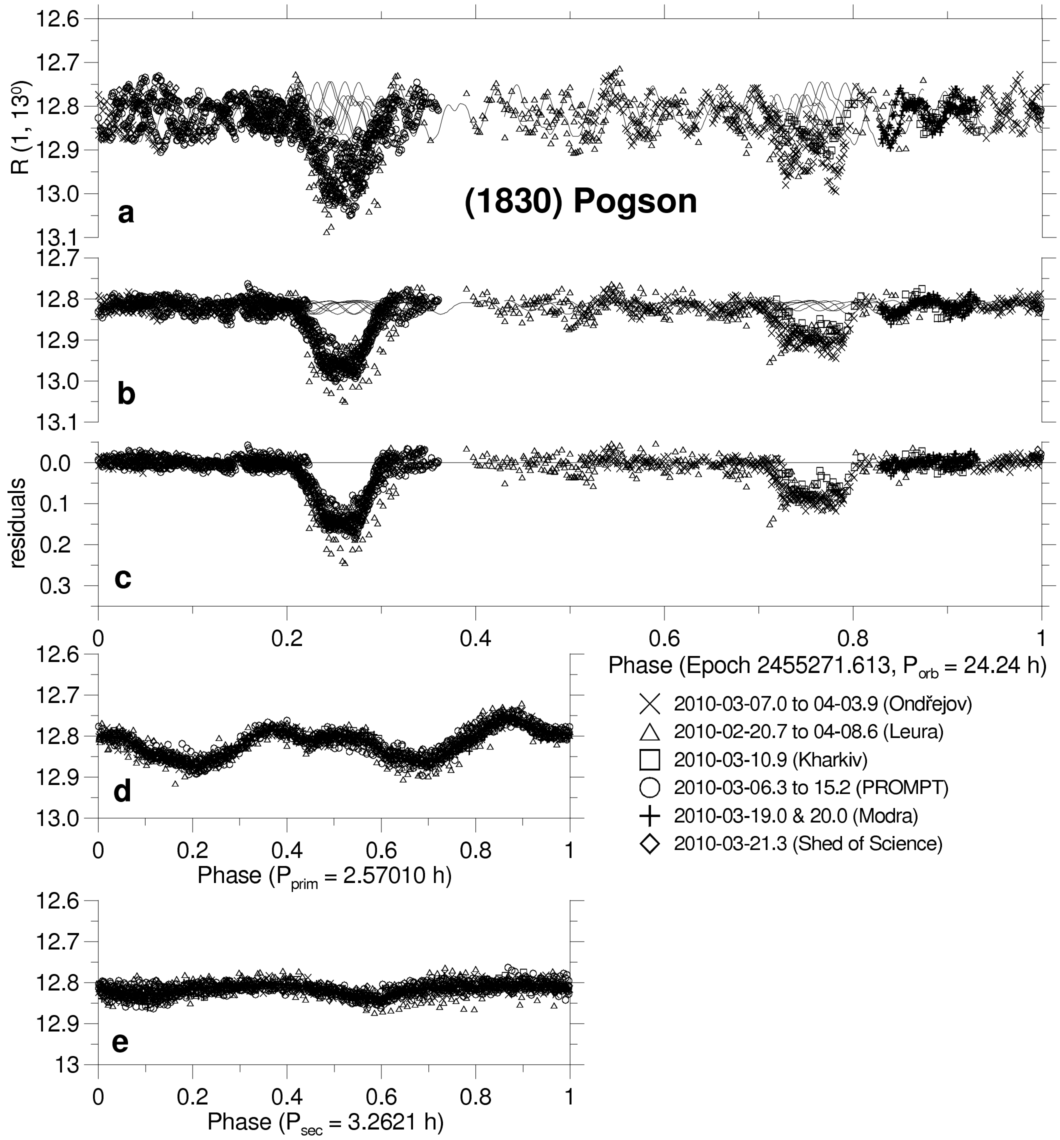
From depths of the secondary mutual events, derived after subtracting both rotational lightcurve components, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.30 \pm 0.02$. If there is present a third body in the system as suggested above, contributing to the total light flux from the system, then the diameter ratio estimate given above is actually a lower limit on D_2/D_1.



Suppl. Fig. 6. Lightcurve data of (1830) Pogson from 2007. (a) The original data showing all three lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and the second rotational component. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, shows the mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.



Suppl. Fig. 7. Lightcurve data of (1830) Pogson from 2008. (a) The original data showing all three lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and the second rotational component. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, shows the mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.



Suppl. Fig. 8. Lightcurve data of (1830) Pogson from 2010. (a) The original data showing all three lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and the second rotational component. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, shows the mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.

(2006) Polonskaya

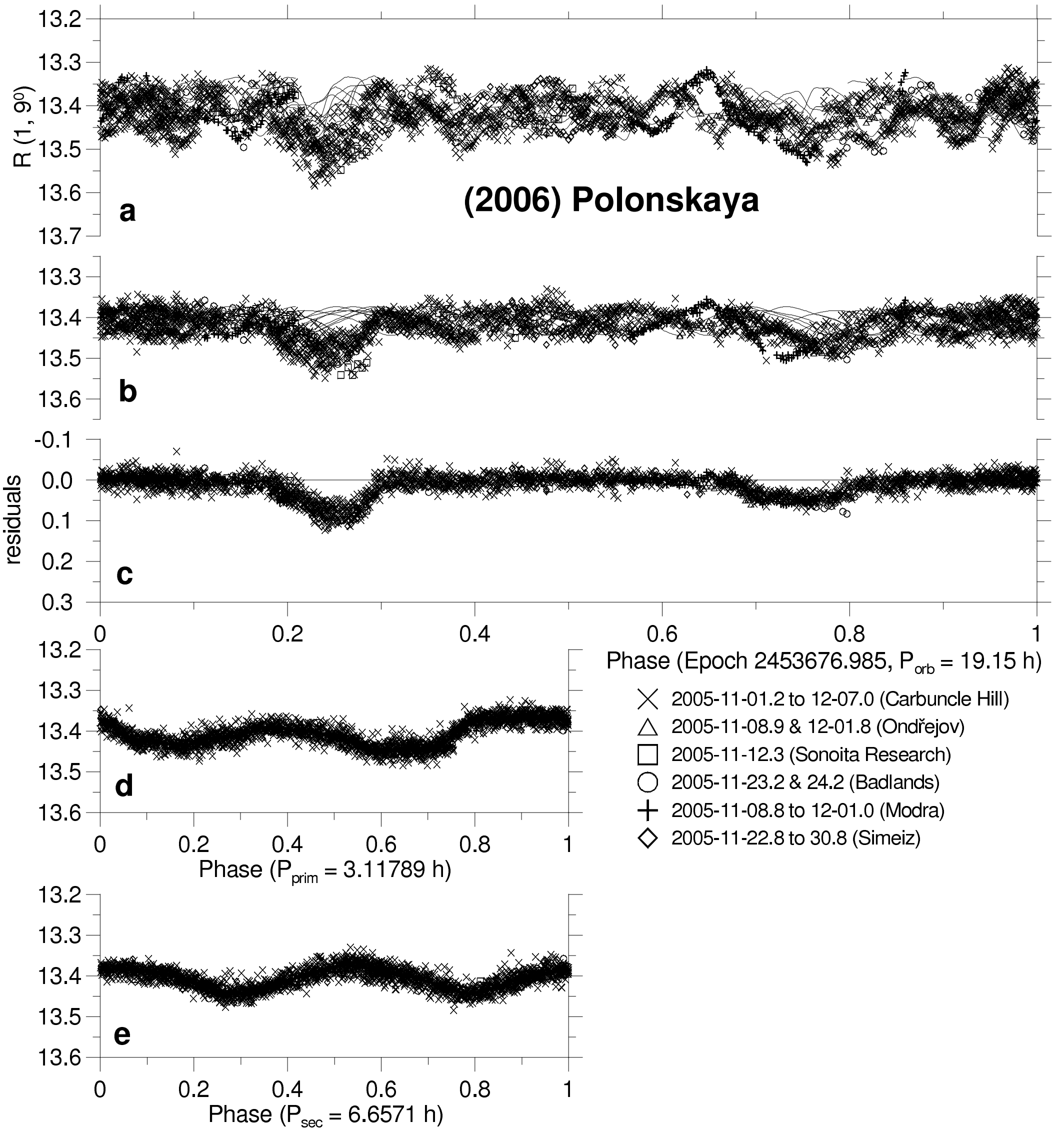
We observed this binary in three apparitions of 2005, 2008 and 2010. Our discovery announcement was Pray et al. (2005). In the discovery apparition, observations from Carbuncle Hill, Ondřejov, Badlands, Modra, Simeiz and Sonoita Research Observatory were taken on 22 nights from 2005-11-01.2 to 12-07.0. The data, shown in Suppl. Fig. 9, revealed the primary lightcurve with period $P_1 = 3.11789 \pm 0.00004$ h ($\Delta P_{\rm syn-sid} = 0.00013$ h) and amplitude $A_1 = 0.08$ mag. These high quality data revealed also a second rotational lightcurve component with period $P_2 = 6.6571 \pm 0.0002$ h ($\Delta P_{\rm syn-sid} = 0.0006$ h) and amplitude $A_2 = 0.07$ mag, shown in Suppl. Fig. 9e. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01-0.02 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 12.97 \pm 0.05$ and slope parameter $G = 0.42 \pm 0.06$.

In the second apparition we observed this binary from Las Campanas on 3 nights from 2008-06-04.4 to 06.3, the data were relative and they are shown in Suppl. Fig. 10. Our analysis of these data provided an estimate of the primary period of $P_1 = 3.114 \pm 0.002$ h and amplitude $A_1 = 0.08$ mag. The second rotational lightcurve component was present in the data and we estimated its period $P_2 = 6.662 \pm 0.009$ h and amplitude $A_2 = 0.09$ mag (see Suppl. Fig. 10e). Despite the observations covered about 60% of the orbit period, there were seen no obvious mutual events, see Suppl. Fig. 10c.

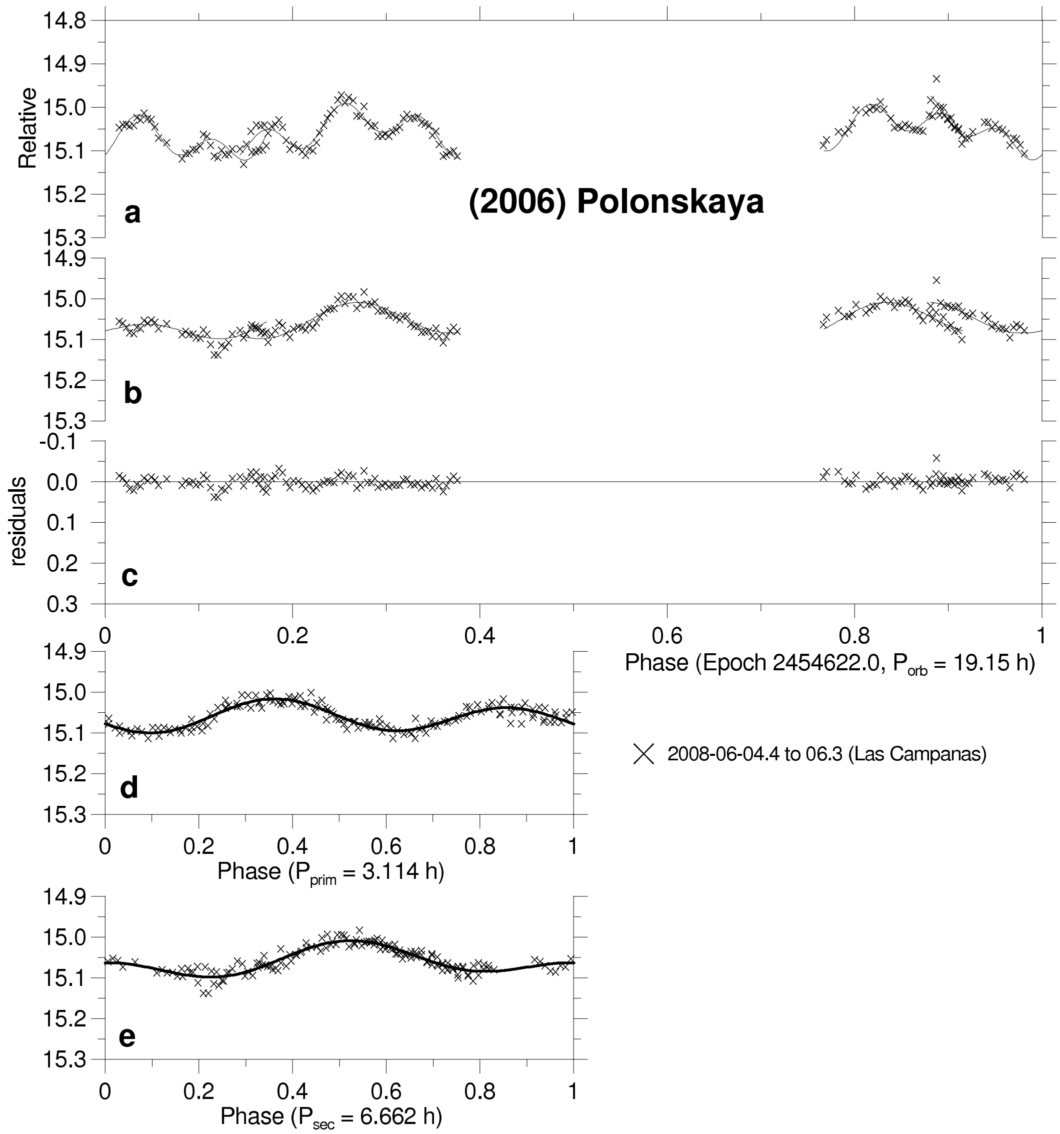
In Suppl. Fig. 11, there are shown data taken in the third apparition from Carbuncle Hill, Ondřejov and Modra on 14 nights from 2010-01-10.2 to 02-22.1. These data provided an estimate of the primary period of $P_1 = 3.11809 \pm 0.00007$ h ($\Delta P_{\rm syn-sid} = 0.00003$ h) with amplitude $A_1 = 0.10$ mag. The data again show a presence of the second rotational component, $P_2 = 6.6593 \pm 0.0004$ h ($\Delta P_{\rm syn-sid} = 0.0001$ h) and $A_2 = 0.10$ mag, and it is shown in Suppl. Fig. 11e. The three Ondřejov nightly sessions were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. Assuming $G = 0.42 \pm 0.06$ from the 2005 apparition, we estimated $H_R = 12.96 \pm 0.03$.

Both rotational components were present at all orbital phases including mutual events, with unchanged shape in the event. The fact that the second rotational component did not disappear in mutual events indicates that it is not a rotation of the secondary. We consider that it may rather belong to a third body in the system. This proposed explanation will have to be confirmed and a size and distance of the third body will have to be estimated with future observations.

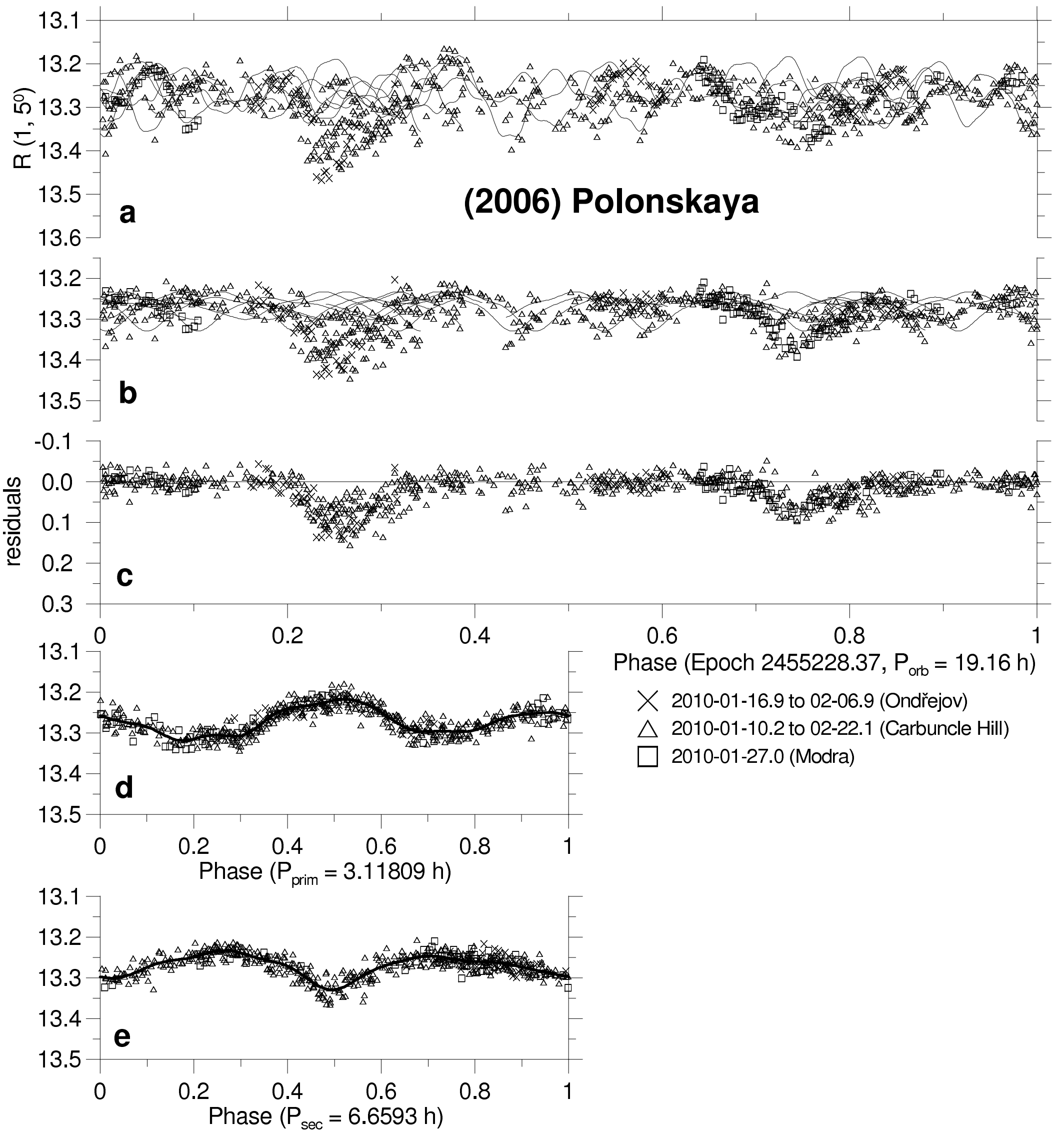
From depths of the secondary mutual events observed in the 2005 and 2010 apparitions, derived after subtracting both rotational lightcurve components, we estimated a lower limit on the secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.23 \pm 0.03$.



Suppl. Fig. 9. Lightcurve data of (2006) Polonskaya from 2005. (a) The original data showing all three lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and the second rotational component. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, shows the mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.



Suppl. Fig. 10. Lightcurve data of (2006) Polonskaya from 2008. (a) The original data showing all three lightcurve components, folded with the orbit period derived in the 2005 apparition. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the second rotational component but no mutual events between components of the binary system. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, showing no mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.



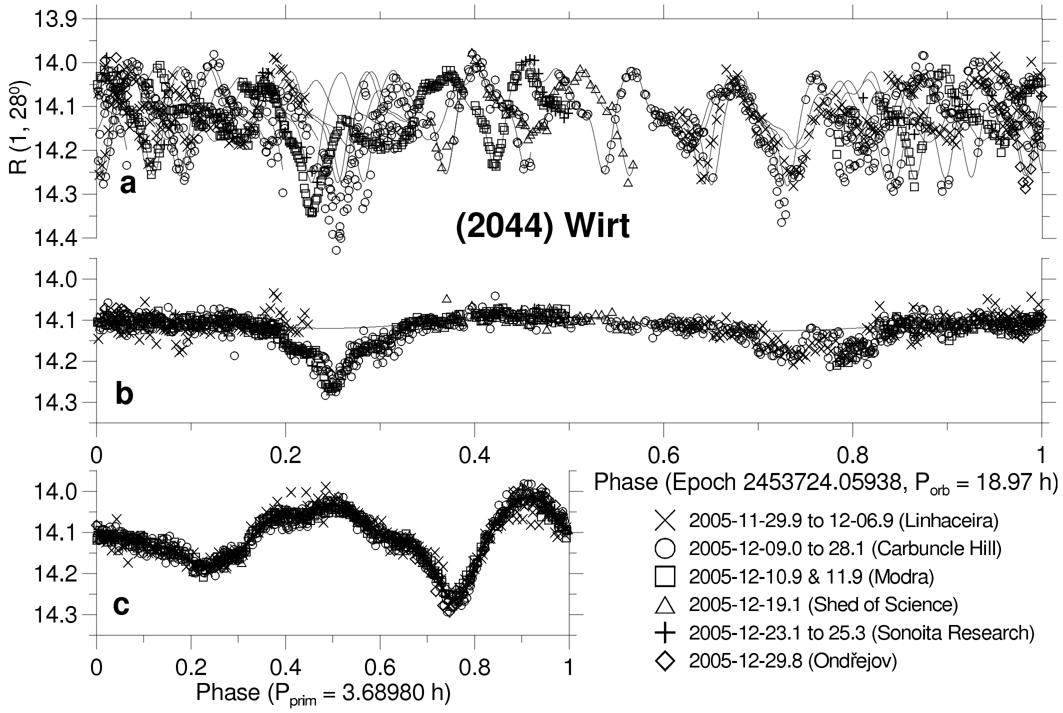
Suppl. Fig. 11. Lightcurve data of (2006) Polonskaya from 2010. (a) The original data showing all three lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and the second rotational component. (c) The orbital lightcurve component, derived after subtraction of the primary and the second lightcurve components, shows the mutual events between components of the binary system. (d) The primary lightcurve component. (e) The second rotational lightcurve component.

(2044) Wirt

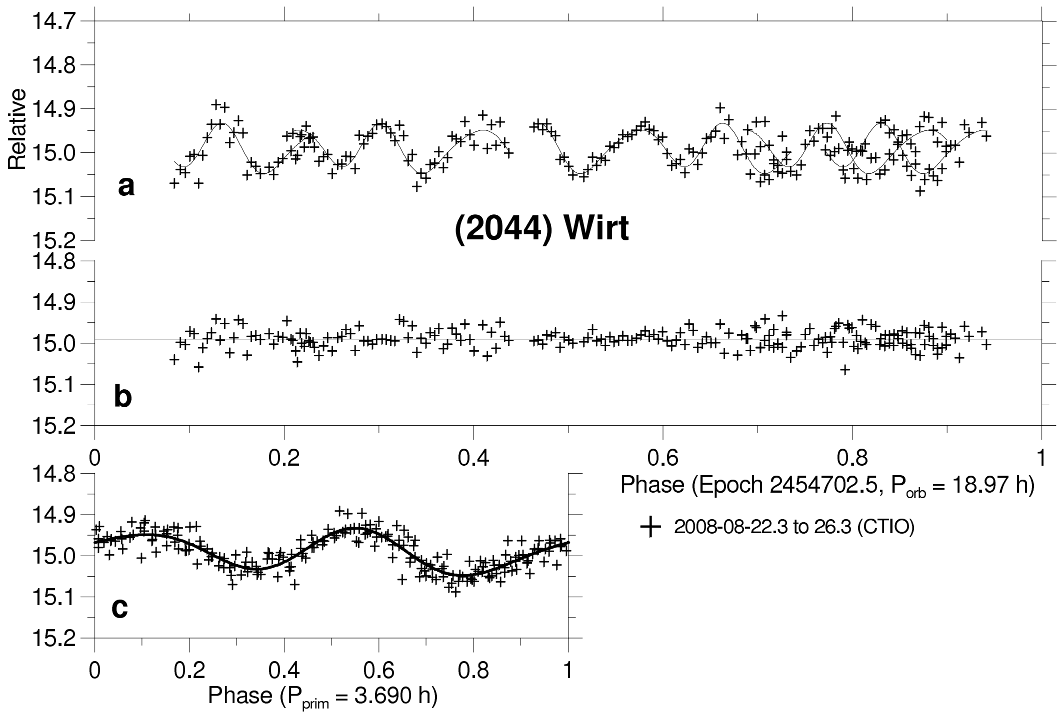
This binary was observed in three apparitions of 2005, 2008 and 2010. Our discovery announcement was Pray et al. (2006a). In the discovery apparition we observed it from Carbuncle Hill, Ondřejov, Modra, Shed of Science, Linhaceira and Sonoita Research Observatory on 24 nights from 2005-11-29.9 to 2006-01-29.8. Suppl. Fig. 12 shows the observations taken from 11-29.9 to 12-29.8. From these data we derived the primary period $P_1 = 3.68980 \pm 0.00004$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0006$ h) and amplitude $A_1 = 0.25$ mag. Though the data are relative, their thorough coverage allowed us to reveal that there was present also a second rotation lightcurve component, consistent with being due to synchronous rotation of the secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.04$ mag (see Suppl. Fig. 12b). From a depth of the secondary event, which was a total event according to our modeling presented in Section 5, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.25 \pm 0.02$. The additional observations taken during 2006-01-09.0 to 29.8 were less abundant, but they contributed to modeling of the system.

Our observations from the second apparition are shown in Suppl. Fig. 13. They were taken from Cerro Tololo Inter-American Observatory on 5 nights from 2008-08-22.3 to 26.3 and showed the primary rotation lightcurve with the same period (within error bars) as that seen in the discovery apparition. The primary amplitude was $A_1 = 0.12$ mag. Despite the observations covered about 90% of the orbit period, there were seen no obvious events, see Suppl. Fig. 13b.

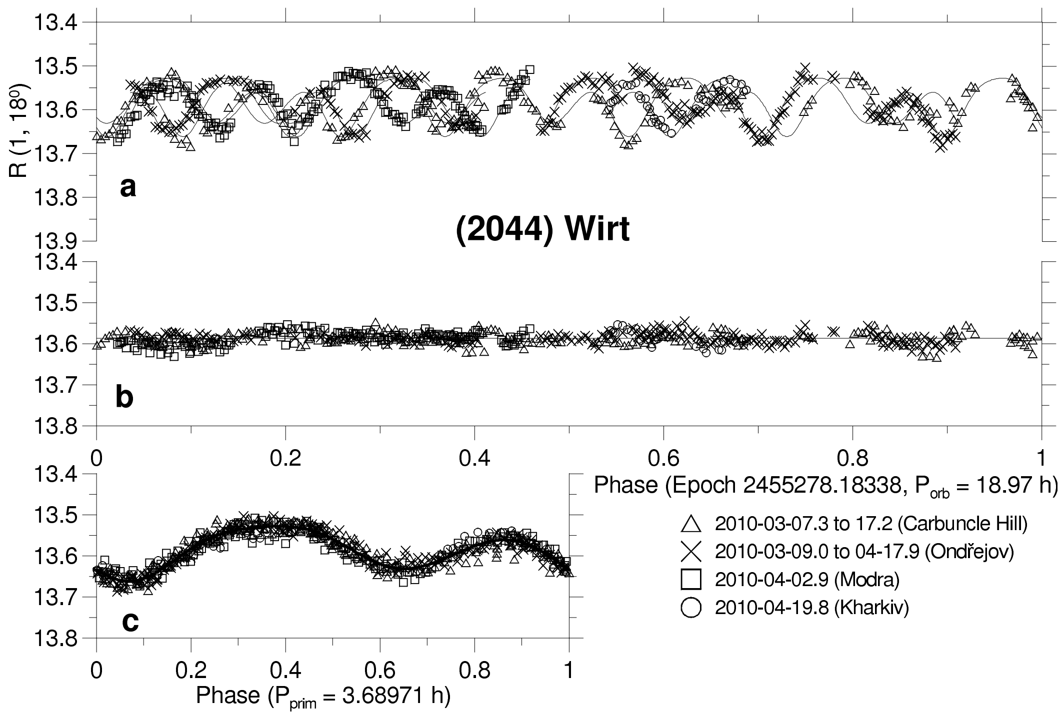
In Suppl. Fig. 14, there are shown data taken on 9 nights in the third apparition, from Carbuncle Hill, Ondřejov, Modra and Kharkiv from 2010-03-07.3 to 04-19.8. From these data we derived the primary period $P_1 = 3.68971 \pm 0.00005$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0003$ h) with amplitude $A_1 = 0.13$ mag. Our observations covered all orbital phases but, similar to the 2008 apparition, no mutual event with depth > 0.03 mag was seen.



Suppl. Fig. 12. Lightcurve data of (2044) Wirt from 2005. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.



Suppl. Fig. 13. Lightcurve data of (2044) Wirt from 2008. (a) The original data showing both lightcurve components, folded with the orbit period derived in the 2005 apparition. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing no prominent mutual events. (c) The primary lightcurve component.



Suppl. Fig. 14. Lightcurve data of (2044) Wirt from 2010. (a) The original data showing both lightcurve components, folded with the orbit period derived in 2005 apparition. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing no prominent mutual events. (c) The primary lightcurve component.

(2577) Litva

We observed this system in two apparitions of 2009 and 2010. Our discovery announcement was Warner et al. (2009a) and results derived from our complete 2009 dataset, 22 nights from 2009-02-28.2 to 04-01.9, were published in Warner et al. (2009d). Here we summarize the results: The primary period and amplitude are $P_1 = 2.81258 \pm 0.00002\,\mathrm{h}$ ($\Delta P_{\mathrm{syn-sid}} = 0.00034$ h) and $A_1 = 0.24\,\mathrm{mag}$. The data revealed also a presence of another, second rotational lightcurve component with a period of $P_2 = 5.6842 \pm 0.0002\,\mathrm{h}$ ($\Delta P_{\mathrm{syn-sid}} = 0.0014$ h) and amplitude $A_2 = 0.09\,\mathrm{mag}$.

Observations of the second apparition, taken on 11 nights from 2010-07-16.3 to 08-31.2, were published in Warner (2011). Our updated solution for the primary period and amplitude is $P_1 = 2.81292 \pm 0.00003\,\mathrm{h}$ ($\Delta P_{\mathrm{syn-sid}} = 0.00009$ h), $A_1 = 0.17\,\mathrm{mag}$, while the estimated period and amplitude of the second rotational lightcurve component, apparent in the 2010 data as well, are $P_2 = 5.6818 \pm 0.0003\,\mathrm{h}$ ($\Delta P_{\mathrm{syn-sid}} = 0.00037$ h), $A_2 = 0.06\,\mathrm{mag}$.

Both rotational components were present at all orbital phases including mutual events, with unchanged shape in the event. The fact that the second rotational component did not disappear in mutual events indicates that it is not a rotation of the secondary. We consider that it may rather belong to a third body in the system. This proposed explanation will have to be confirmed and a size and distance of the third body will have to be estimated with future observations.

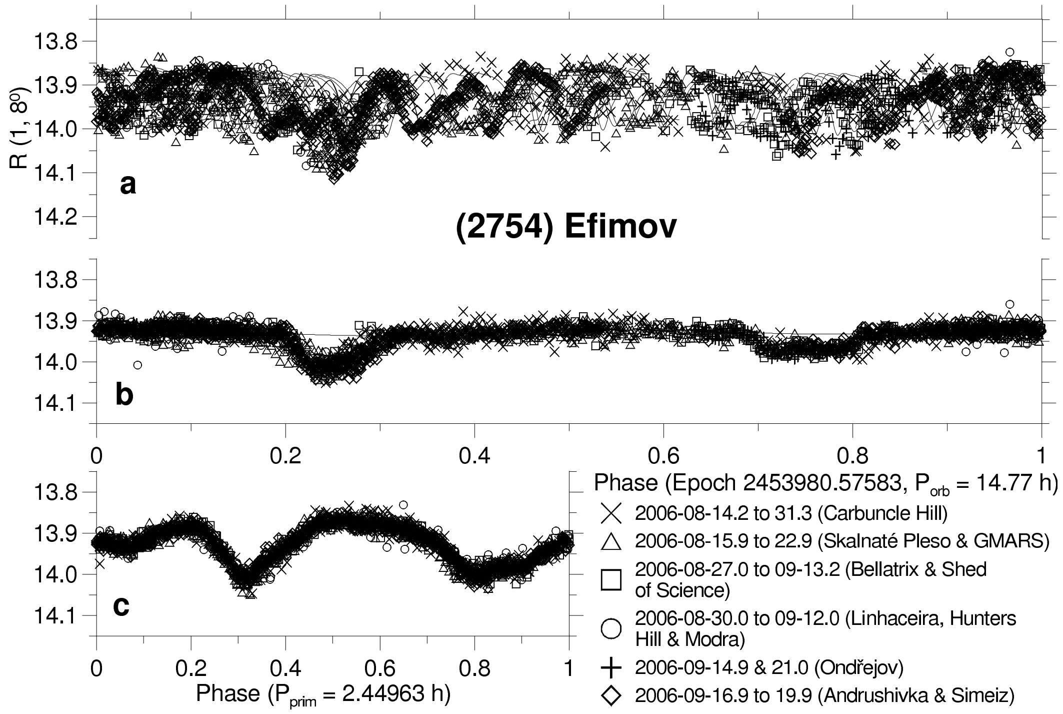
From depth of the secondary mutual events observed in 2009, derived after subtracting both rotational lightcurve components, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.34 \pm 0.02$. Though we did not see a flat bottom in the secondary events and thus we could not tell whether the events were total from the data directly, our subsequent modeling presented in Section 5 revealed that the events were indeed total. However, if there is present a third body in the system as suggested above, contributing to the total light flux from the system, then the diameter ratio estimate given above is actually a lower limit on D_2/D_1.

(2754) Efimov

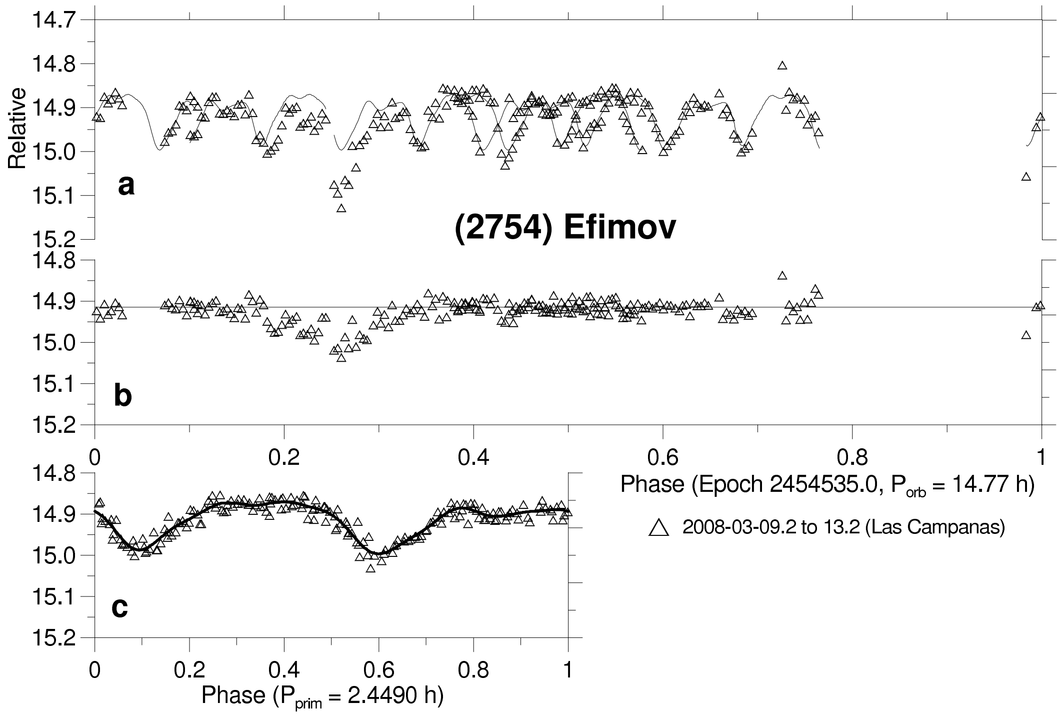
We observed this binary in three apparitions of 2006, 2008 and 2011. Our discovery announcement was Pray et al. (2006c). In the discovery apparition, the high quality data were taken from Carbuncle Hill, Ondřejov, Skalnaté Pleso, GMARS, Modra, Hunters Hill, Andrushivka, Simeiz, Shed of Science, Bellatrix and Linhaceira on 31 nights from 2006-08-14.2 to 11-18.1. Suppl. Fig. 15 shows data taken during 08-14.2 to 09-21.0. We estimated the primary period $P_1 = 2.44963 \pm 0.00001$ h ($\Delta P_{\text{syn}-\text{sid}} = 0.0001$ h) and $A_1 = 0.14$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. The calibrated data revealed that there was present also a second rotation lightcurve component, consistent with being due to synchronous rotation of elongated secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.02$ mag (see Suppl. Fig. 15b). The additional observations taken during 10-10.5 to 11-18.1 are of a similar quality but with less abundant coverage than the data shown in Suppl. Fig. 15. A purpose of the extended observations was monitoring evolution of the mutual events for modeling of the binary.

In the second apparition we observed this binary from Las Campanas on 4 nights from 2008-03-9.2 to 13.2, the data were relative and they are shown in Suppl. Fig. 16. Our analysis of these data provided an estimate of the primary period of $P_1 = 2.4490 \pm 0.0003$ h ($\Delta P_{\text{syn}-\text{sid}} = 0.00003$ h) and amplitude $A_1 = 0.13$ mag.

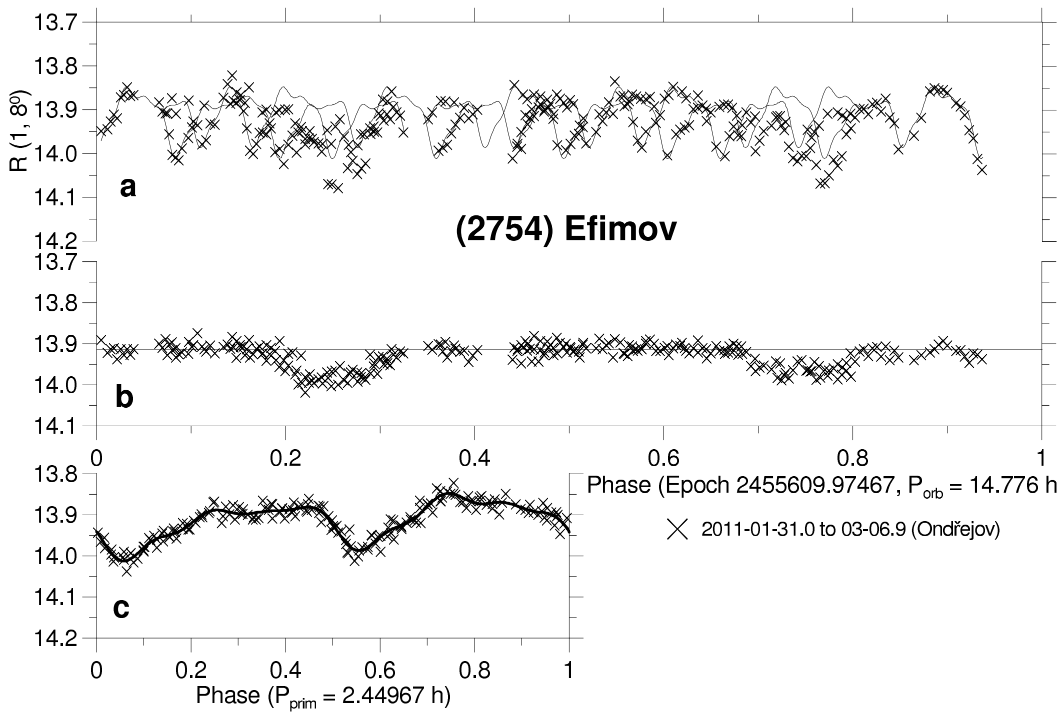
In the third apparition we observed this binary from Ondřejov on 4 nights from 2011-01-31.0 to 03-06.9. The data are shown in Suppl. Fig. 17. We estimated the primary period $P_1 = 2.44967 \pm 0.00002$ h ($\Delta P_{\text{syn}-\text{sid}} = 0.00001$ h) and amplitude $A_1 = 0.16$ mag. From a depth of the secondary event that appeared to be total as there was seen a flat bottom of the event on 01-31.0 and 02-25.9, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.22 \pm 0.02$. The observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.02 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 13.43 \pm 0.02$ and slope parameter $G = 0.29 \pm 0.02$.



Suppl. Fig. 15. Lightcurve data of (2754) Efimov from 2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.



Suppl. Fig. 16. Lightcurve data of (2754) Efimov from 2008. (a) The original data showing both lightcurve components, folded with the orbit period derived in 2006. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



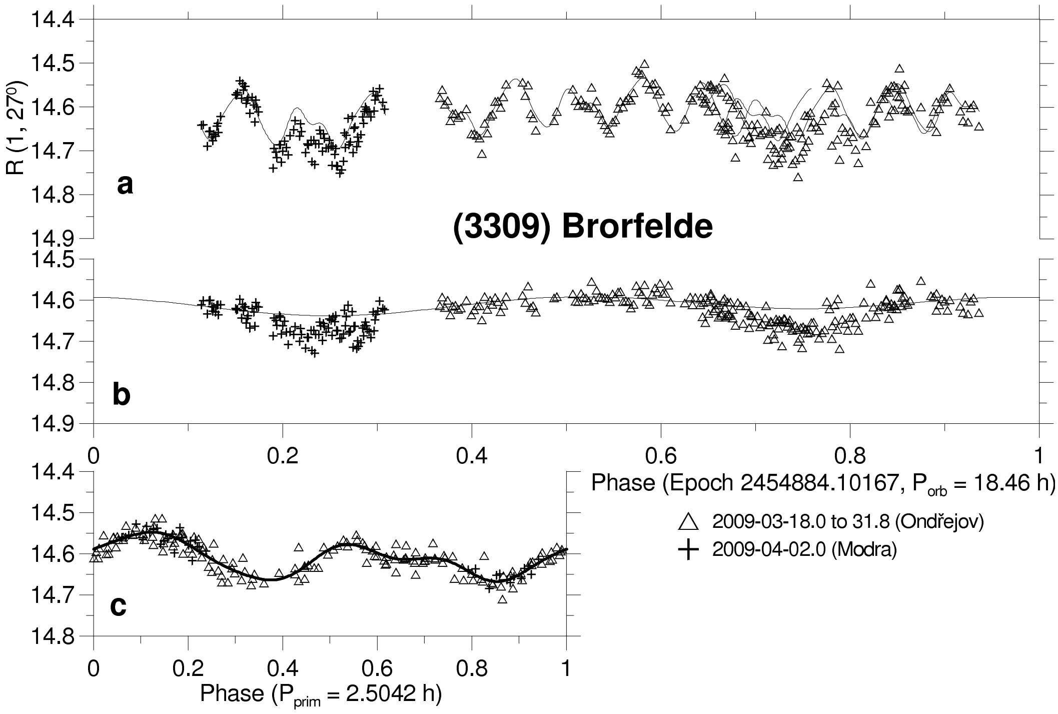
Suppl. Fig. 17. Lightcurve data of (2754) Efimov from 2011. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

(3309) Brorfelde

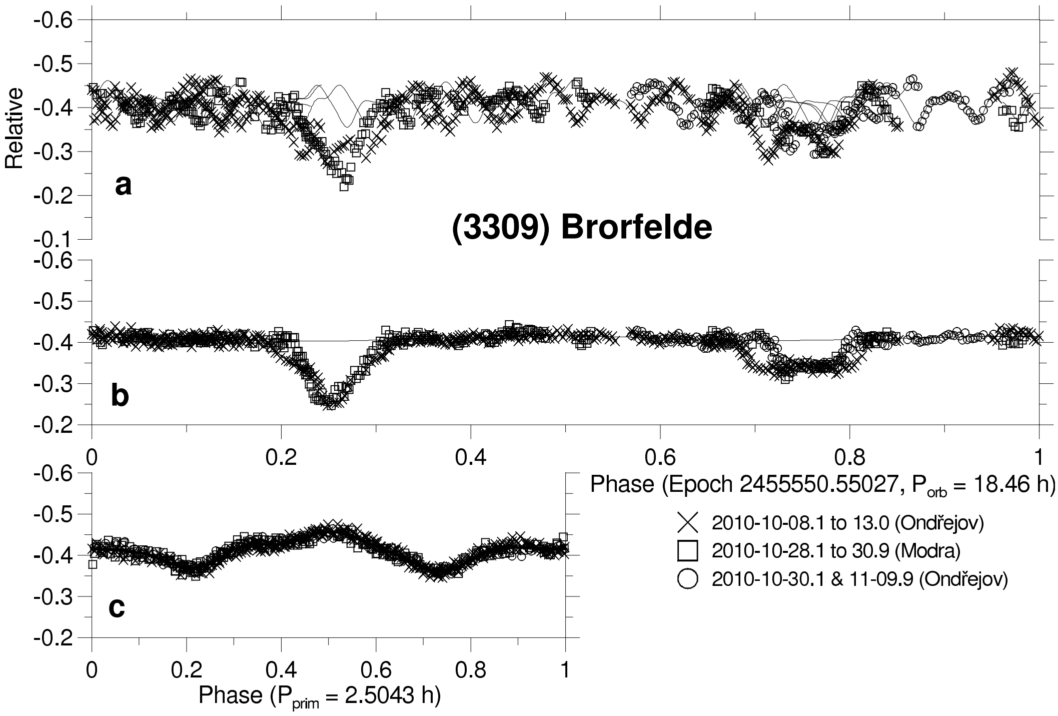
We observed this binary in three apparitions of 2005, 2009 and 2010. Our discovery announcement was Warner et al. (2005c). Data from the discovery apparition, taken from Palmer Divide Observatory, Ondřejov, Elginfield and Sonoita Research Observatory on 9 nights from 2005-10-25.2 to 11-03.2, were published in Warner et al. (2011). Our updated solution for the primary period and amplitude is $P_1 = 2.5041 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0002$ h), $A_1 = 0.09$ mag. The Ondřejov observations were subsequently absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. The calibrated data revealed that there was present also a second rotation lightcurve component with period $P_2 = 18.45 \pm 0.02$ h. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.04$ mag. From the calibrated data we derived also the asteroid's absolute magnitude $H_R = 13.48 \pm 0.04$, assuming $G = 0.22 \pm 0.05$ derived from observations taken in 2010 (see below).

In the second apparition we observed this binary on 13 nights from 2009-01-28.3 to 04-02.0. Data from the first interval, taken from Palmer Divide Observatory during 01-28.3 to 02-03.3, were published in Warner (2009). From a depth of the secondary event that appeared to be total as there was seen a flat bottom of the event on 01-29.4, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.26 \pm 0.02$. The additional observations were taken from Ondřejov and Modra on 6 nights during 03-18.0 to 04-02.0 and they are shown in Suppl. Fig. 18. They revealed the primary's lightcurve with period $P_1 = 2.5042 \pm 0.0002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0002$ h) and amplitude $A_1 = 0.12$ mag. The five Ondřejov nightly sessions were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.02 mag. From the data we derived the asteroid's absolute magnitude $H_R = 13.50 \pm 0.07$, assuming $G = 0.22 \pm 0.05$ estimated from the 2010 observations.

In the third apparition we observed this binary from Ondřejov, Modra, Sonoita Research Observatory, Simeiz and PROMPT on 19 nights from 2010-10-08.1 to 12-26.2. Suppl. Fig. 19 shows observations taken during 10-08.1 to 11-09.9. We derived the primary period of $P_1 = 2.5043 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0001$ h) with amplitude $A_1 = 0.10$ mag. The Ondřejov observations were mutually linked in an instrumental magnitude system with an internal consistency of 0.01 mag. The linked data revealed that there was present also a second rotation lightcurve component, consistent with being due to synchronous rotation of elongated secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.02$ mag (see Suppl. Fig. 19b). They also provided an estimate for the slope parameter of $G = 0.22 \pm 0.05$. The additional observations taken from 11-11.8 to 12-26.2 monitored evolution of the mutual events for modeling of the system.



Suppl. Fig. 18. Lightcurve data of (3309) Brorfelde from 2009. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.

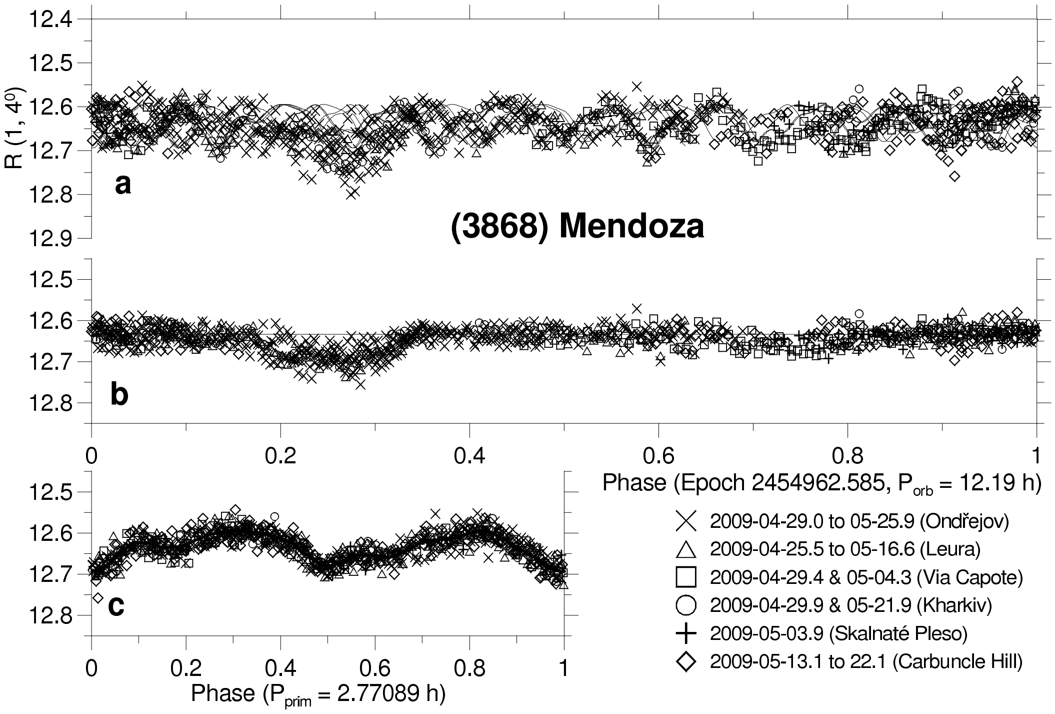


Suppl. Fig. 19. Lightcurve data of (3309) Brorfelde from 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.

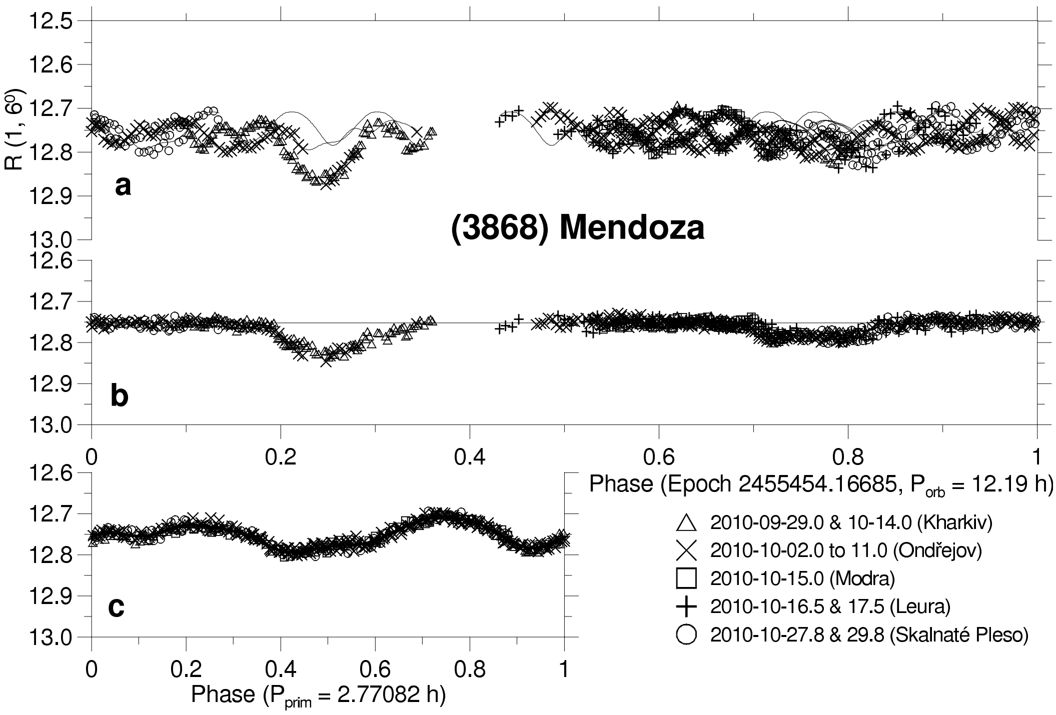
(3868) Mendoza

We have got good quality data for this binary in two apparitions of 2009 and 2010. In the discovery apparition observations from Leura, Ondřejov, Carbuncle Hill, Via Capote, Kharkiv and Skalnaté Pleso were taken on 18 nights from 2009-04-25.5 to 05-25.9. The data are shown in Suppl. Fig. 20. We estimated the primary period $P_1 = 2.77089 \pm 0.00005$ h and $A_1 = 0.10$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.02 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 12.29 \pm 0.03$ and slope parameter $G = 0.22 \pm 0.03$. Our discovery announcement on the binary was Oey et al. (2009). Note that in the discovery CBET, there was given an orbit period estimate twice as large as we have estimated analysing the high quality observations of 2010; in our initial analysis of the noisier data of 2009, the very shallow secondary event was not recognized and we fixed this error in our final analysis.

In the second apparition we observed this binary from Ondřejov, Skalnaté Pleso, Kharkiv, Modra, Leura and Simeiz on 21 nights from 2010-09-07.0 to 11-14.8. Suppl. Fig. 21 shows observations from 09-29.0 to 10-29.8. They provided an estimate of the primary period of $P_1 = 2.77082 \pm 0.00005$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00007$ h) and $A_1 = 0.09$ mag. The additional observations taken from 09-07.0 to 11-14.8 were of a slightly lower quality but they contributed to modeling of the system. Eight of the ten Ondřejov nightly sessions were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.02 mag and they revealed the asteroid's absolute magnitude $H_R = 12.30 \pm 0.02$ and slope parameter $G = 0.21 \pm 0.03$. From a depth of the secondary event that appeared to be total as the best observations showed it having a flat bottom, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.17 \pm 0.02$.



Suppl. Fig. 20. Lightcurve data of (3868) Mendoza from 2009. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



Suppl. Fig. 21. Lightcurve data of (3868) Mendoza from 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

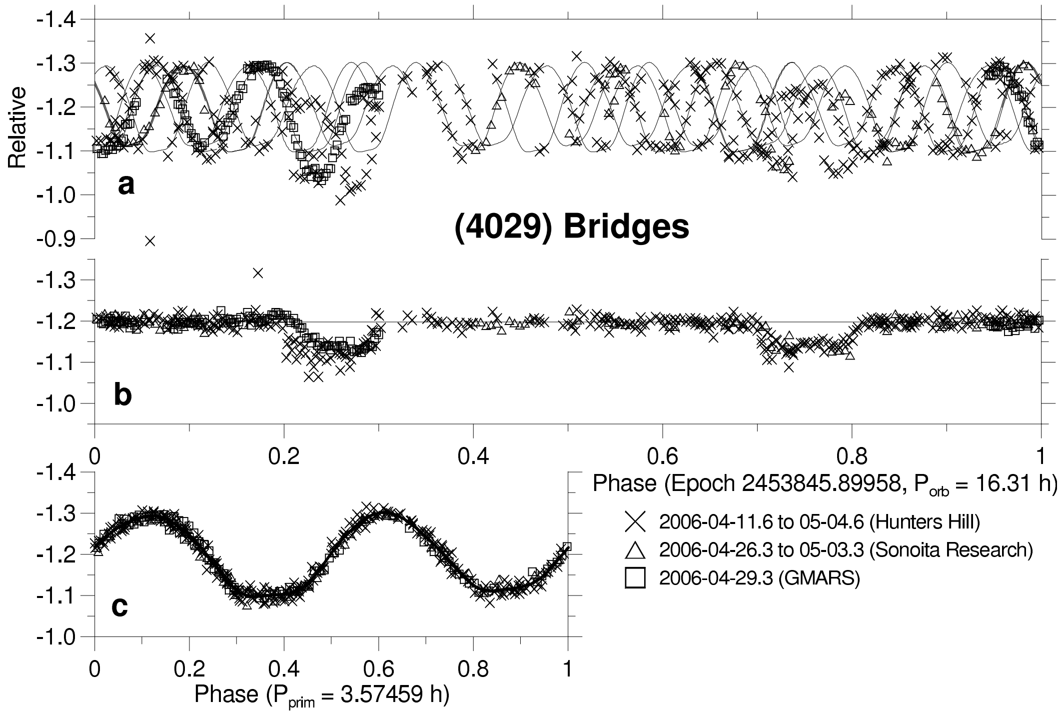
(4029) Bridges

We observed this binary in three apparitions of 2006, 2007 and 2010. Our discovery announcement was Higgins et al. (2006c). Data from the discovery apparition, taken from Hunters Hill, Sonoita Research Observatory and GMARS on 11 nights from 2006-04-11.6 to 05-04.6 are shown in Suppl. Fig. 22. The data were relative and provided an estimate of the primary period $P_1 = 3.57459 \pm 0.00007$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0001$ h) and amplitude $A_1 = 0.20$ mag.

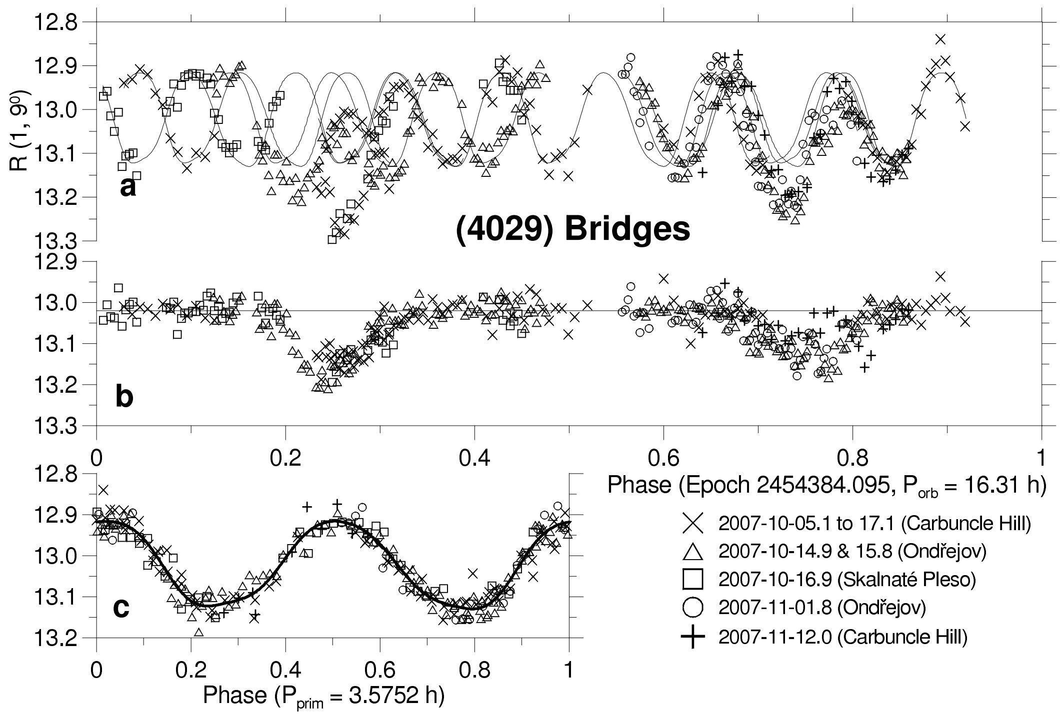
In the second apparition, observations from Carbuncle Hill, Ondřejov and Skalnaté Pleso, were taken on 8 nights from 2007-10-05.1 to 11-12.0 and are shown in Suppl. Fig. 23. We estimated the primary period $P_1 = 3.5752 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0001$ h) and amplitude $A_1 = 0.21$ mag. Two of the three Ondřejov nightly sessions were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag and they gave the asteroid's absolute magnitude $H_R = 12.40 \pm 0.10$, assuming the slope parameter $G = 0.15 \pm 0.2$.

Data taken in the third apparition from Hunters Hill, PROMPT and Kharkiv on 10 nights from 2010-05-08.5 to 06-09.2 were split into two sub-intervals showing a changed shape of the primary lightcurve component. Data from the first interval from 05-08.5 to 19.5 provided an estimate of the primary period $P_1 = 3.5754 \pm 0.0002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.0001$ h) and amplitude $A_1 = 0.23$ mag. These data are shown in Suppl. Fig. 24. The data from the second interval are shown in Suppl. Fig. 25 and provided an estimate of $P_1 = 3.5752 \pm 0.0002$ h and $A_1 = 0.29$ mag.

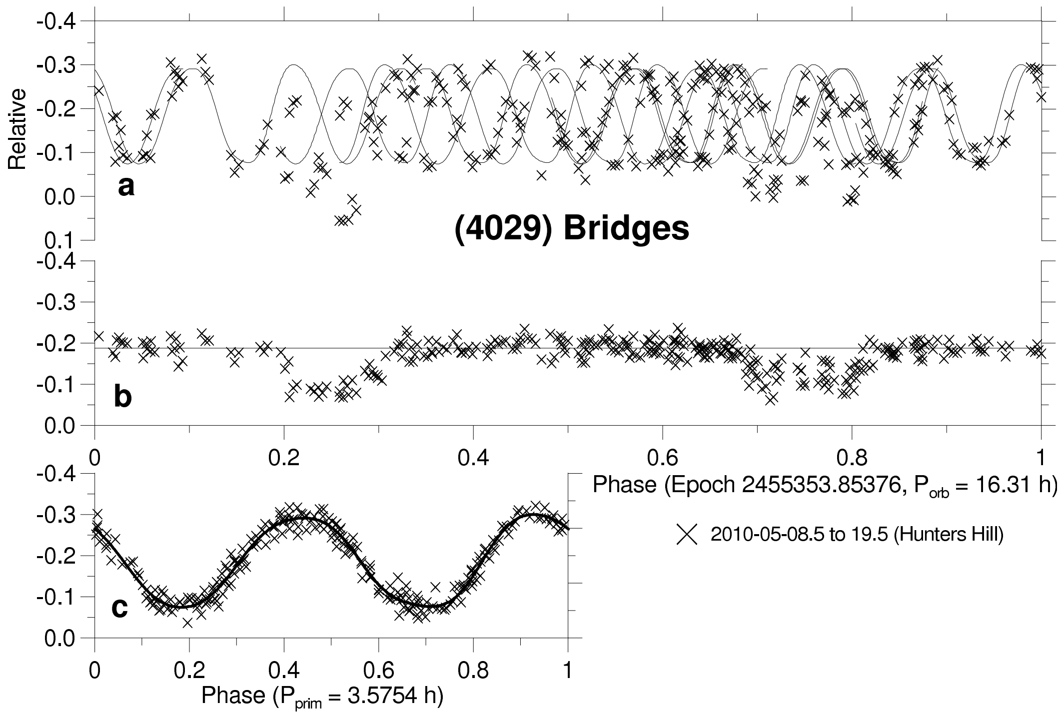
From observed depths of the secondary events, we got estimates of the secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.24$, 0.30, and 0.26 in the three apparitions. The estimates were made with assuming that the events were total. While the varying event depths might suggest that the mutual events were not fully total in the first and the third apparition, the orbit modeling presented in Section 5 gives that they all were total. This apparent discrepancy will have to be resolved with future observations and more detailed modeling; e.g., it might be caused by a precession of the satellite orbit if it is slightly inclined to the primary's equator.



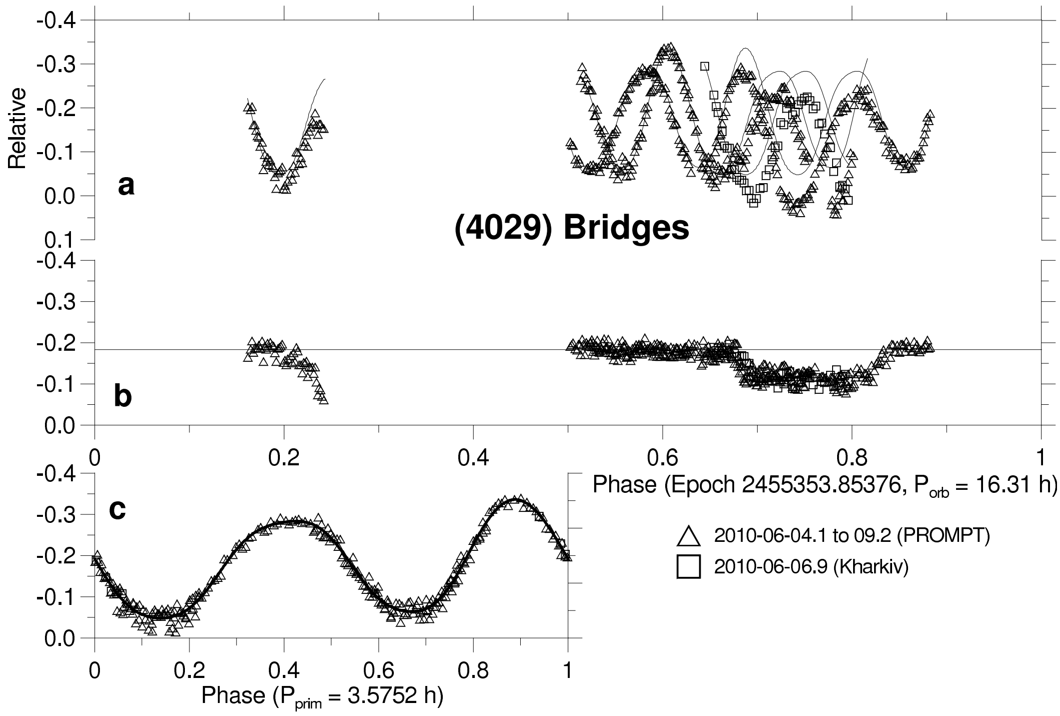
Suppl. Fig. 22. Lightcurve data of (4029) Bridges from 2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



Suppl. Fig. 23. Lightcurve data of (4029) Bridges from 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



Suppl. Fig. 24. Lightcurve data of (4029) Bridges from May 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



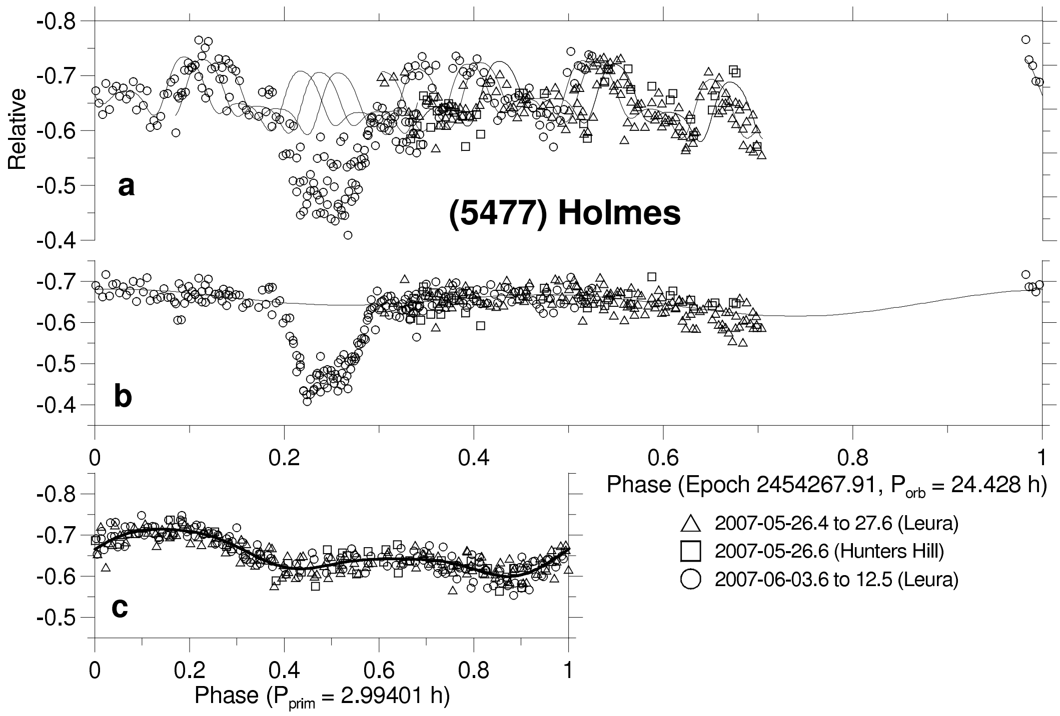
Suppl. Fig. 25. Lightcurve data of (4029) Bridges from June 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

(5477) Holmes

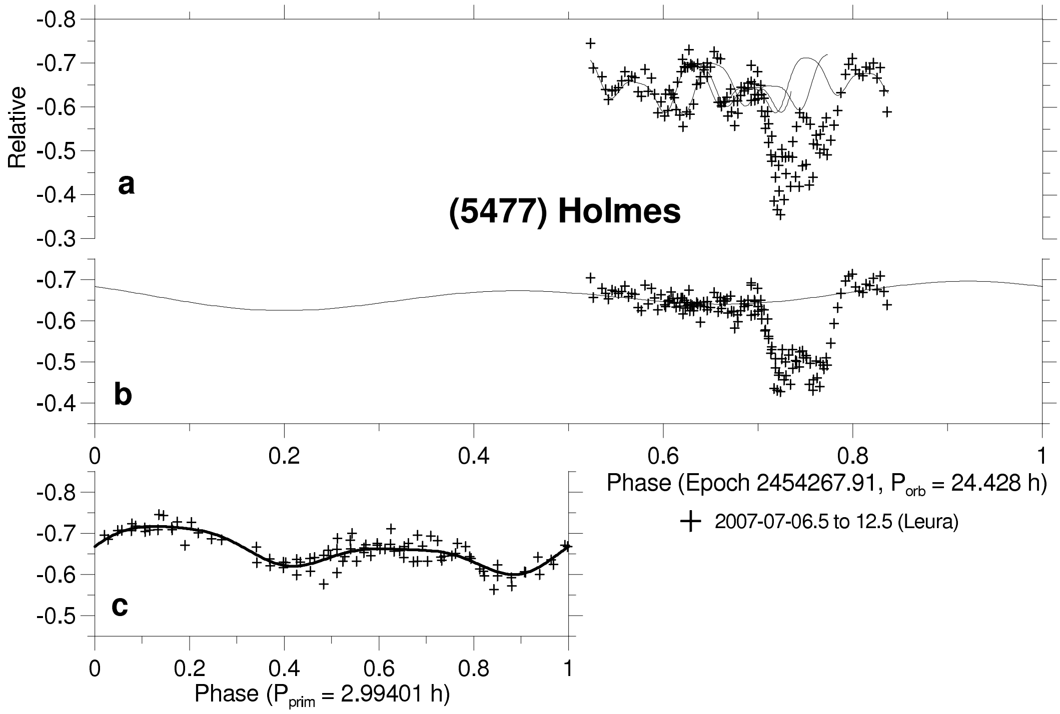
We observed this binary in two apparitions of 2005 and 2007. Our discovery announcement was Warner et al. (2005d). Data from the discovery apparition, taken from Palmer Divide Observatory, Modra, Badlands, Ondřejov, Hunters Hill, Carbuncle Hill, Sonoita Research Observatory and Campo Catino on 16 nights between 2005-11-02.3 and 12-08.9, were published in Warner et al. (2011). Here we summarize their results: the primary period and amplitude were $P_1 = 2.99408 \pm 0.00007$ h ($\Delta P_{\rm syn-sid} = 0.00024$ h) and $A_1 = 0.10$ mag. A second rotation lightcurve component was also resolved. It is consistent with being due to synchronous rotation of the secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.04$ mag. Two sessions from Ondřejov of 2005-11-09.0 and 12-05.9 at solar phases 2.0° and 18.5°, respectively, were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. From the data, we derived the binary's mean absolute magnitude $H_R = 13.99 \pm 0.03$ and slope parameter $G = 0.39 \pm 0.03$; the stated errors account for the calibration uncertainties of the two sessions but they may be only a lower limit on real uncertainties of the phase relation parameters if there were additional error sources affecting the H, G estimation.

In the second apparition, observations from Leura and Hunters Hill were taken on 9 nights from 2007-05-26.4 to 07-12.5. The shape of the primary lightcurve slightly changed during the observing interval, the data from May–June 2007 are presented in Suppl. Fig. 26 and those from July are in Suppl. Fig. 27. We estimated the primary period $P_1 = 2.99401 \pm 0.00007$ h ($\Delta P_{\rm syn-sid} = 0.00021$ h) and amplitude $A_1 = 0.12$ mag from the whole dataset. A synchronous secondary's lightcurve was apparent as well, with amplitude A_2 similar to that seen in the 2005 apparition but its accurate estimate could not be made because of a limited coverage of the period.

The flat bottom of the observed secondary events as well as our modeling presented in Section 5 indicate that the mutual events were total in both apparitions. From depth of the total secondary events, we estimated the secondary-to-primary mean diameter ratio $D_2/D_1 = 0.39 \pm 0.02$.



Suppl. Fig. 26. Lightcurve data of (5477) Holmes from May–June 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.



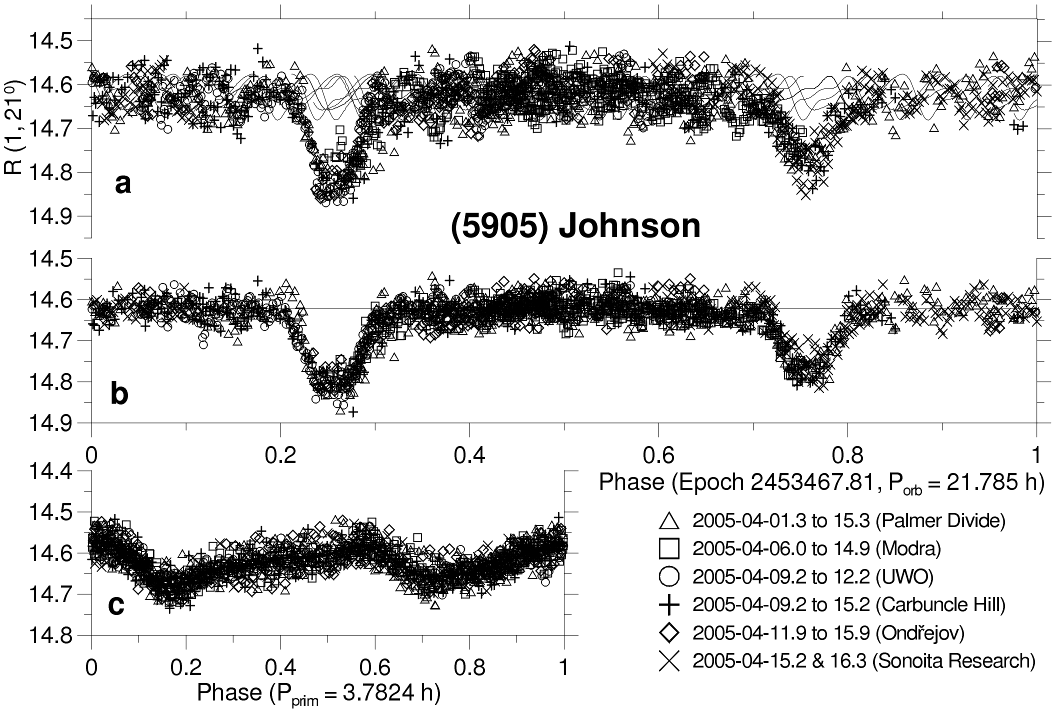
Suppl. Fig. 27. Lightcurve data of (5477) Holmes from July 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system. A secondary rotational variation is also apparent, but its fit is only tentative as the coverage was limited. (c) The primary lightcurve component.

(5905) Johnson

This binary was observed in two apparitions of 2005 and 2008. Our discovery announcement was Warner et al. (2005a). In the discovery apparition we observed it from Palmer Divide Observatory, Ondřejov, Modra, Carbuncle Hill, Elginfield and Sonoita Research Observatory on 16 nights between 2005-04-01.3 and 05-04.9. Suppl. Fig. 28 shows the observations on 13 nights taken from 04-01.3 to 16.3. From these data we derived the primary period $P_1 = 3.7824 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00017$ h) and amplitude $A_1 = 0.10$ mag. The additional observations taken during 05-02.0 to 04.9 were less abundant, covering only the primary event, but they contributed to modeling of the system. The Ondřejov observations (5 nights) were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 13.6 \pm 0.3$ assuming slope parameter $G = 0.15 \pm 0.2$.

During the second apparition the binary was observed on 26 nights from 2008-05-02.3 to 07-06.0. A major part of data was published in Warner et al. (2009b). Our updated solution for the primary period and amplitude is $P_1 = 3.78222 \pm 0.00008$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00019$ h), $A_1 = 0.08$ mag.

The secondary events appear to have a flat bottom in both apparitions, though its short duration and noise in the data makes it to be a somewhat marginal indication of a total event. From depth of the secondary events, we estimated a secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.38 \pm 0.02$.

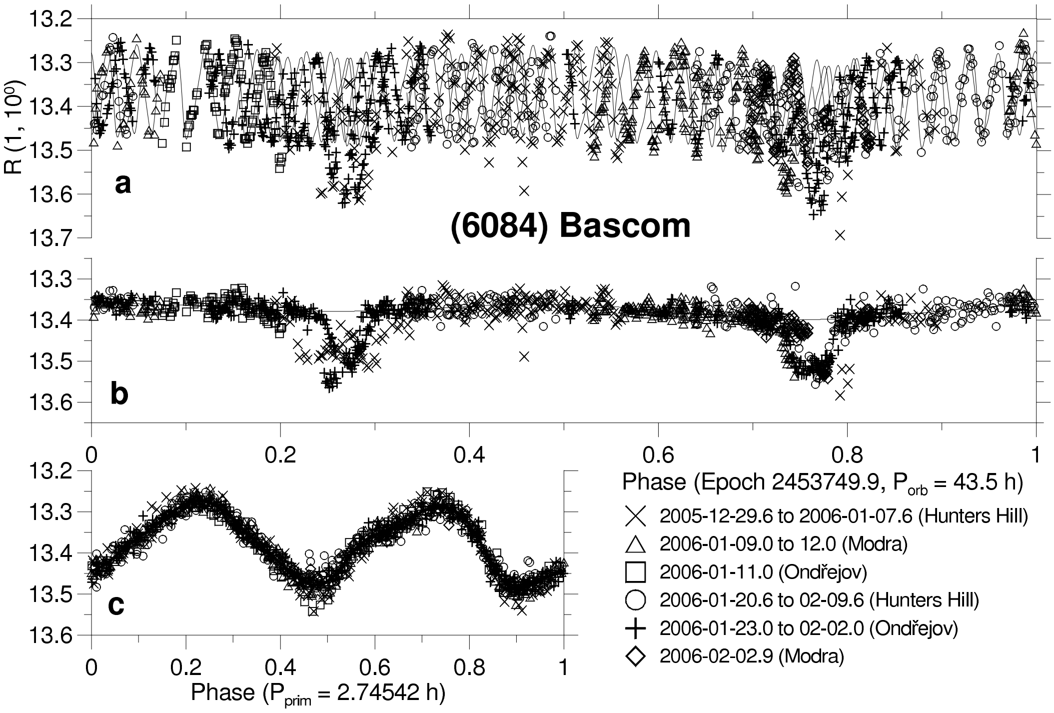


Suppl. Fig. 28. Lightcurve data of (5905) Johnson from 2005. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

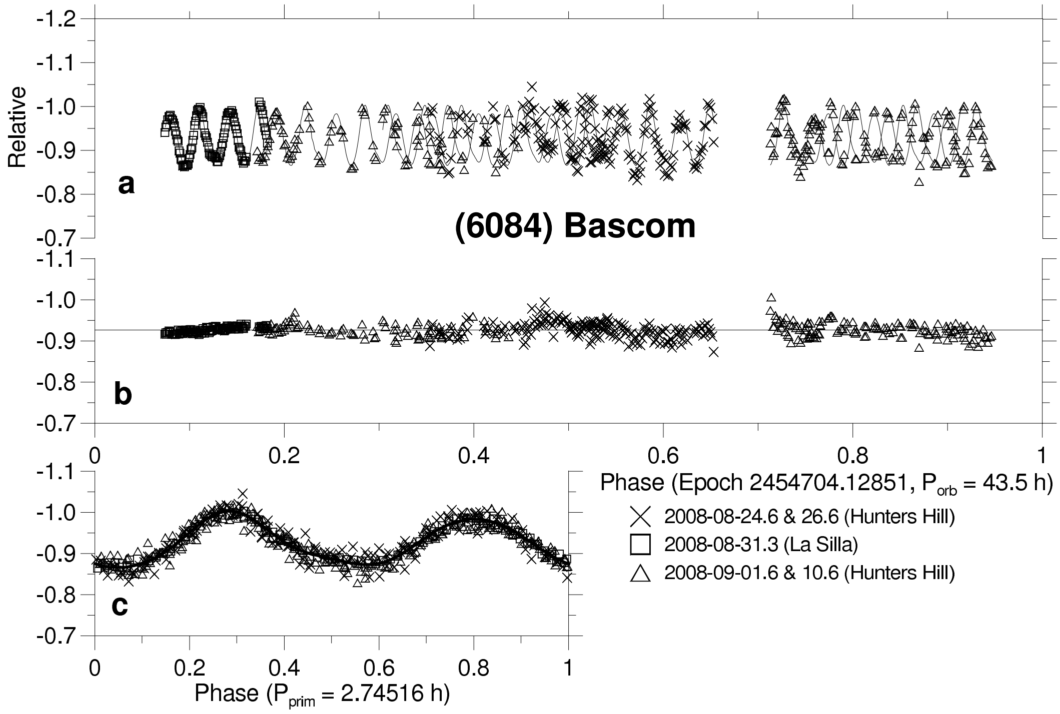
(6084) Bascom

This binary was observed in two apparitions of 2005/2006 and 2008. Our discovery announcement was Higgins et al. (2006a). In the discovery apparition, the observations were taken from Hunters Hill, Ondřejov and Modra on 22 nights from 2005-12-29.6 to 2006-02-09.6. The data are shown in Suppl. Fig. 29. We estimated the primary period $P_1 = 2.74542 \pm 0.00002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00014$ h) and $A_1 = 0.22$ mag. The Ondřejov observations (8 nights) were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.02 mag. The data revealed that a second rotation lightcurve component was also present, it is consistent with being due to synchronous rotation of the secondary. An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.04$ mag (Suppl. Fig. 29b). A flat bottom of the secondary event, best seen in the data of 2006-01-23.0, indicates that the mutual event was total. From depth of the total secondary events, we estimated the secondary-to-primary mean diameter ratio $D_2/D_1 = 0.37 \pm 0.02$. The events showed a relatively rapid evolution, typical for relatively wide systems. From the calibrated data, we derived the asteroid's absolute magnitude $H_R = 12.80 \pm 0.03$ and slope parameter $G = 0.26 \pm 0.05$.

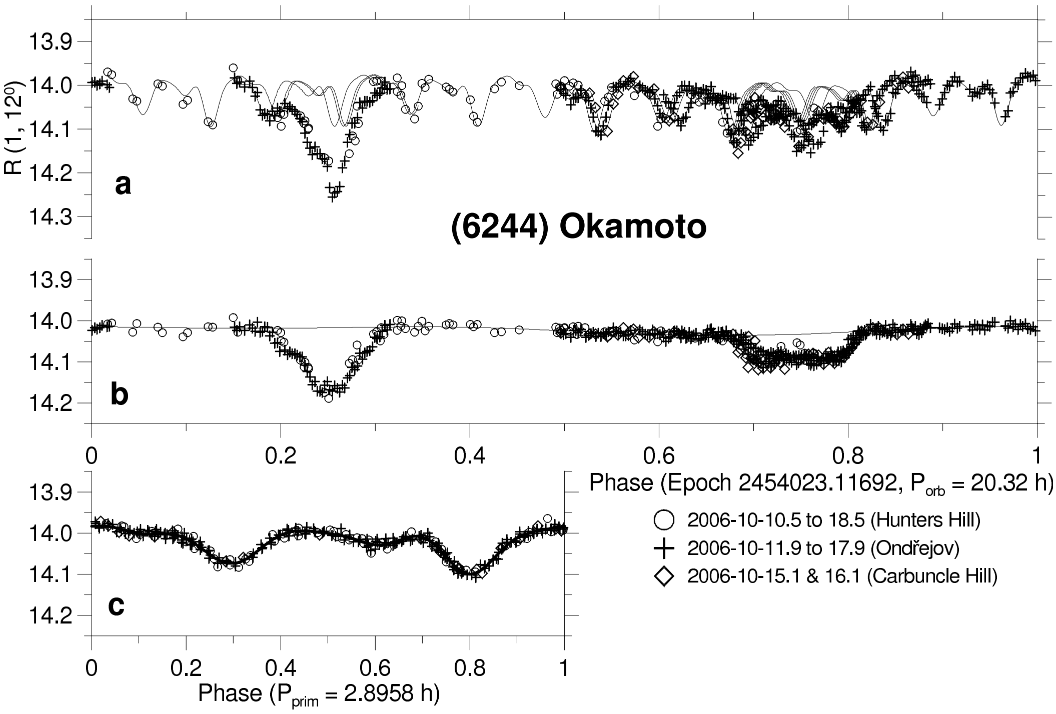
In the second apparition we observed the binary from Hunters Hill and La Silla on 7 nights from 2008-08-24.6 to 09-10.6, the data were relative and they are shown in Suppl. Fig. 30. Our analysis of these data provided estimates of the primary rotation period $P_1 = 2.74516 \pm 0.00006$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00021$ h) and amplitude $A_1 = 0.14$ mag. Despite the observations covered about 80% of the orbit period, no obvious mutual event was seen (Suppl. Fig. 30b).



Suppl. Fig. 29. Lightcurve data of (6084) Bascom from 2005/2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.



Suppl. Fig. 30. Lightcurve data of (6084) Bascom from 2008. (a) The original data showing both lightcurve components, folded with the orbit period derived in the 2005/2006 apparition. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing no prominent mutual events. (c) The primary lightcurve component.

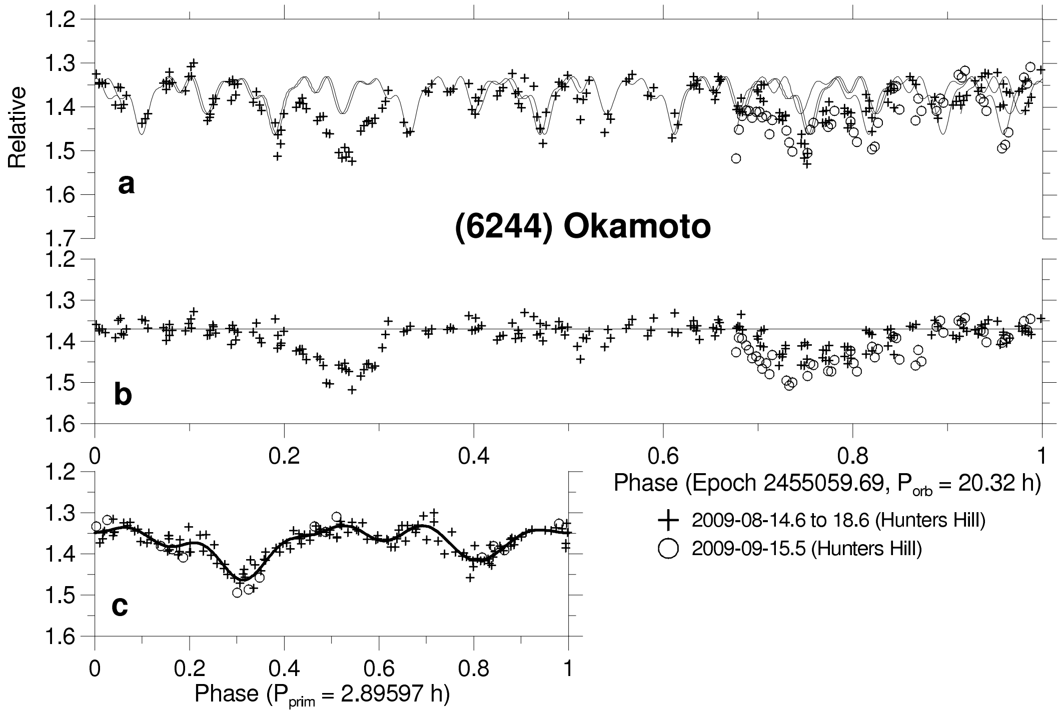


Suppl. Fig. 31. Lightcurve data of (6244) Okamoto from October 2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

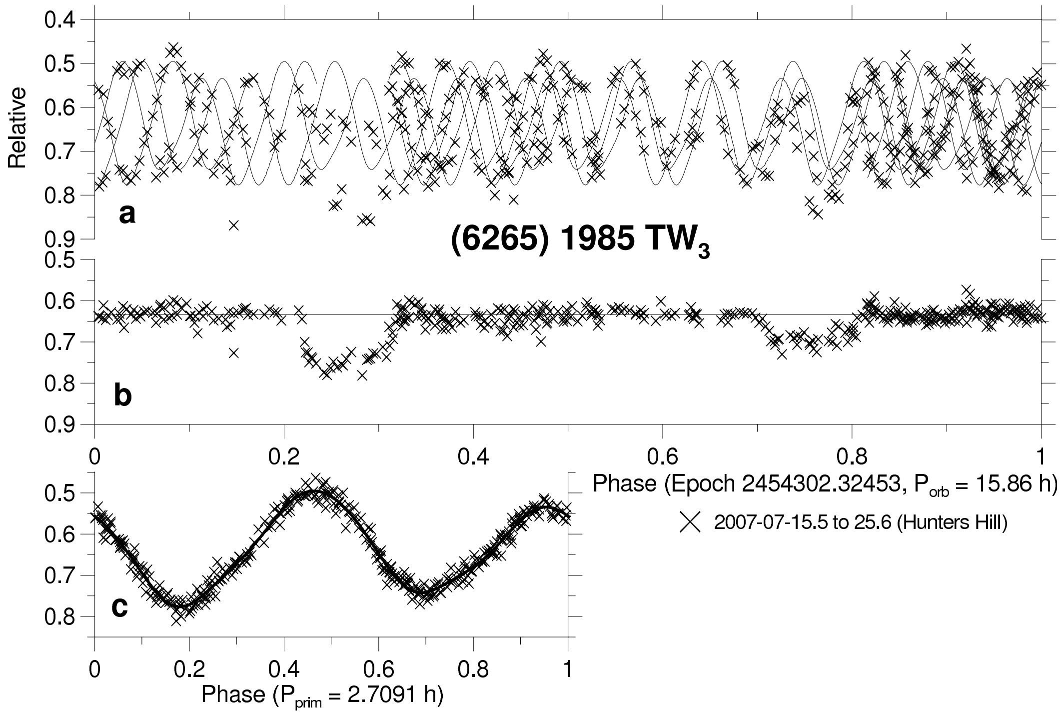
(6244) Okamoto

This binary was observed in two apparitions of 2006 and 2009. Our discovery announcement was Higgins et al. (2006d). In the discovery apparition, the observations were taken from Hunters Hill, Carbuncle Hill, Ondřejov and GMARS on 15 nights from 2006-09-26.2 to 11-26.2, split in three intervals. The best estimate for the primary period was obtained from analysis of the data from the interval 10-10.5 to 18.5: $P_1 = (2.8955 \pm 0.0001)$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00013$ h), with amplitude $A_1 = 0.12$ mag. A formal fit to all data from the whole interval 09-26.2 to 11-26.2 gave $P_1 = 2.8958$ h, but it could be affected by a stronger synodic effect. The four Ondřejov nights were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. From the data, we derived the asteroid's absolute magnitude $H_R = 13.41 \pm 0.04$ and slope parameter $G = 0.28 \pm 0.04$. The observations showed that the secondary events had a flat bottom, indicating that the mutual events were total. From depth of the total secondary events, we estimated the secondary-to-primary mean diameter ratio $D_2/D_1 = 0.25 \pm 0.02$.

In the 2009 apparition, the observations were taken from Hunters Hill on 5 nights from 2009-08-14.6 to 09-15.5. The data were relative and they are shown in Suppl. Fig. 32. Our analysis of these data provided an estimate of the primary rotation period $P_1 = 2.89597 \pm 0.00009$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00010$ h) and amplitude $A_1 = 0.13$ mag.



Suppl. Fig. 32. Lightcurve data of (6244) Okamoto from 2009. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



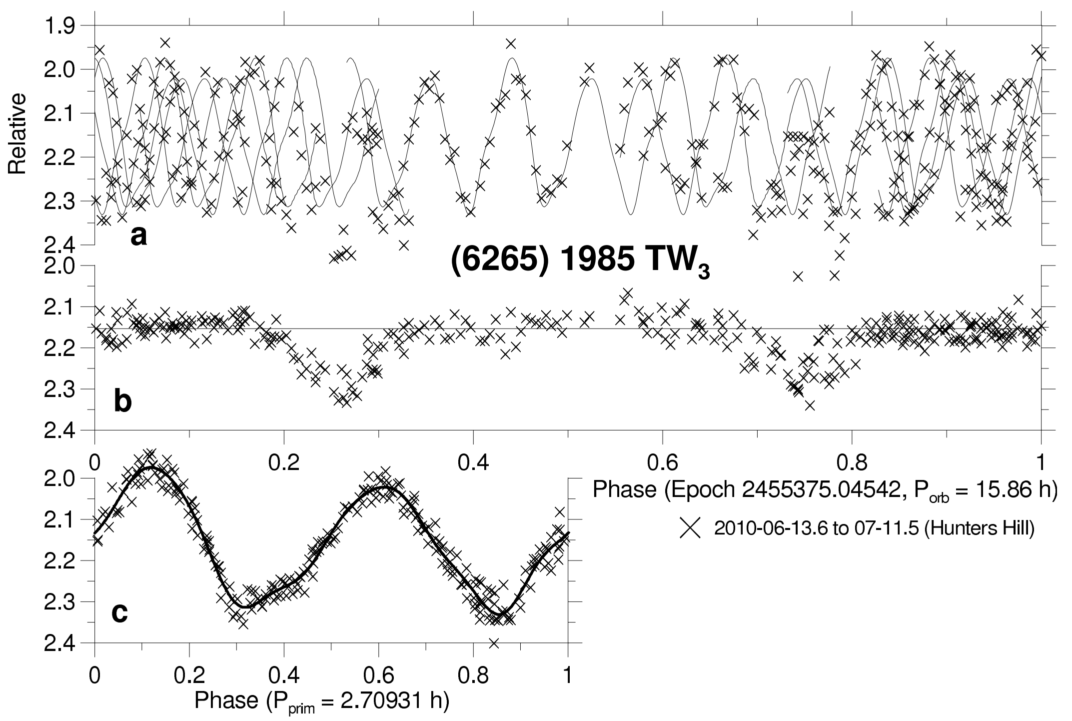
Suppl. Fig. 33. Lightcurve data of (6265) 1985 TW$_3$ from 2007. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

(6265) 1985 TW$_3$

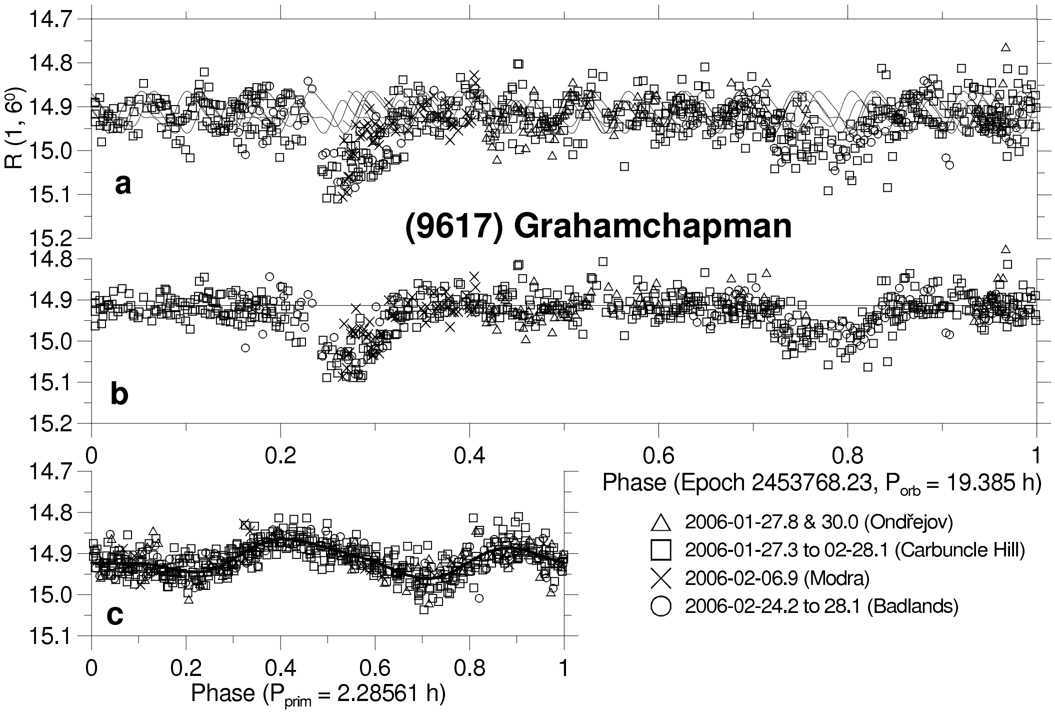
This binary was observed in two apparitions of 2007 and 2010. Our discovery announcement was Higgins et al. (2007b). In the discovery apparition, the observations were taken from Hunters Hill on 19 nights from 2007-07-15.5 to 09-13.5. In Suppl. Fig. 33 we show high quality data from the first 7 nights (between 07-15.5 and 25.6) that provided an estimate of the primary period of $P_1 = 2.7091 \pm 0.0001$ h and amplitude $A_1 = 0.28$ mag.

In the 2010 apparition, the observations were taken from Hunters Hill on 6 nights from 2010-06-13.6 to 07-11.5. Our analysis of these data (Suppl. Fig. 34) provided an estimate of the primary rotation period $P_1 = 2.70931 \pm 0.00005$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00010$ h) and amplitude $A_1 = 0.36$ mag.

From depth of the secondary events in the return apparition, we estimated a lower limit on the secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.32 \pm 0.02$. In the first apparition the events were less deep, suggesting that they were only partial. Though their bottoms appeared approximately flat, we consider that a part of the secondary remained unobscured in the mutual events and their shapes only mimicked total events. A precise estimation of the diameter ratio will require more data and modeling in the future.



Suppl. Fig. 34. Lightcurve data of (6265) 1985 TW$_3$ from 2010. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.



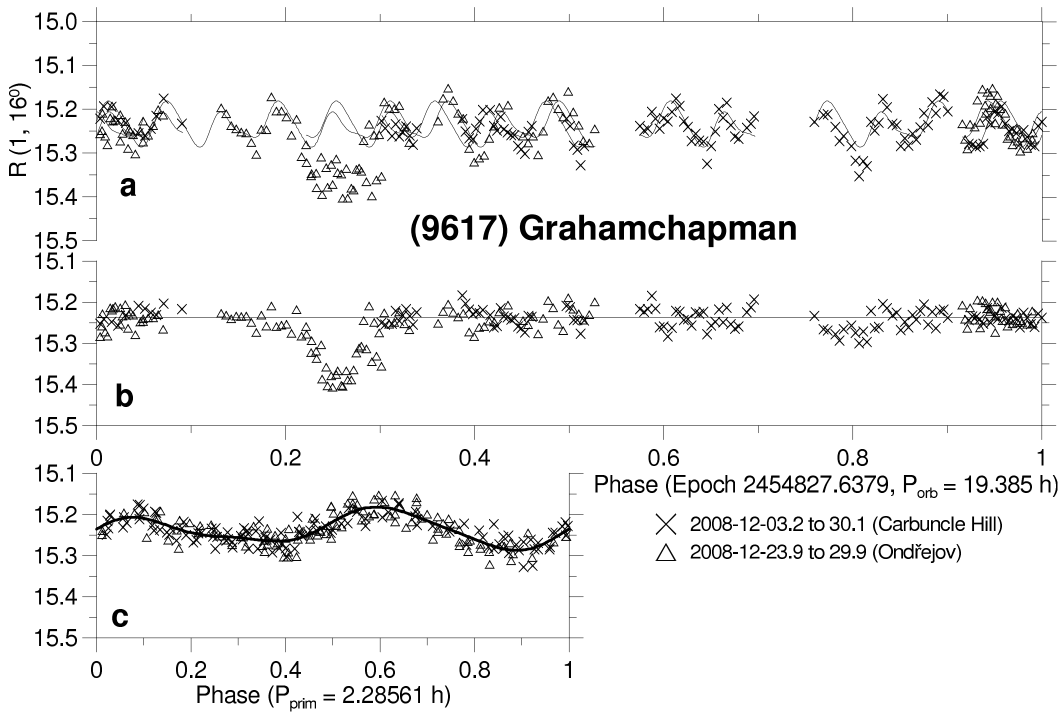
Suppl. Fig. 35. Lightcurve data of (9617) Grahamchapman from 2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

(9617) Grahamchapman

This binary was observed in two apparitions of 2006 and 2008. Our discovery announcement was Pray et al. (2006b). In the discovery apparition, the observations were taken from Carbuncle Hill, Ondřejov, Badlands and Modra on 17 nights from 2006-01-27.3 to 02-28.1. The data (Suppl. Fig. 35) provided an estimate of the primary period of $P_1 = 2.28561 \pm 0.00006$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00004$ h) with amplitude $A_1 = 0.10$ mag. The flat bottom of the secondary event indicates that the mutual event was total. From depth of the total secondary events, we estimated a lower limit on the secondary-to-primary mean diameter ratio of $D_2/D_1 = 0.27 \pm 0.03$.

In the 2008 apparition, the observations were taken from Carbuncle Hill and Ondřejov on 6 nights from 2008-12-03.2 to 30.1. Our analysis of these data (Suppl. Fig. 36) provided an estimate of the primary rotation period $P_1 = 2.28561 \pm 0.00009$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00005$ h) and amplitude $A_1 = 0.11$ mag.

The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag in discovery apparition and 0.02 mag in the return apparition. From these data and assuming $G = 0.15 \pm 0.20$ we estimated the absolute magnitude $H_R = 14.43 \pm 0.10$ and $H_R = 14.37 \pm 0.23$, respectively.

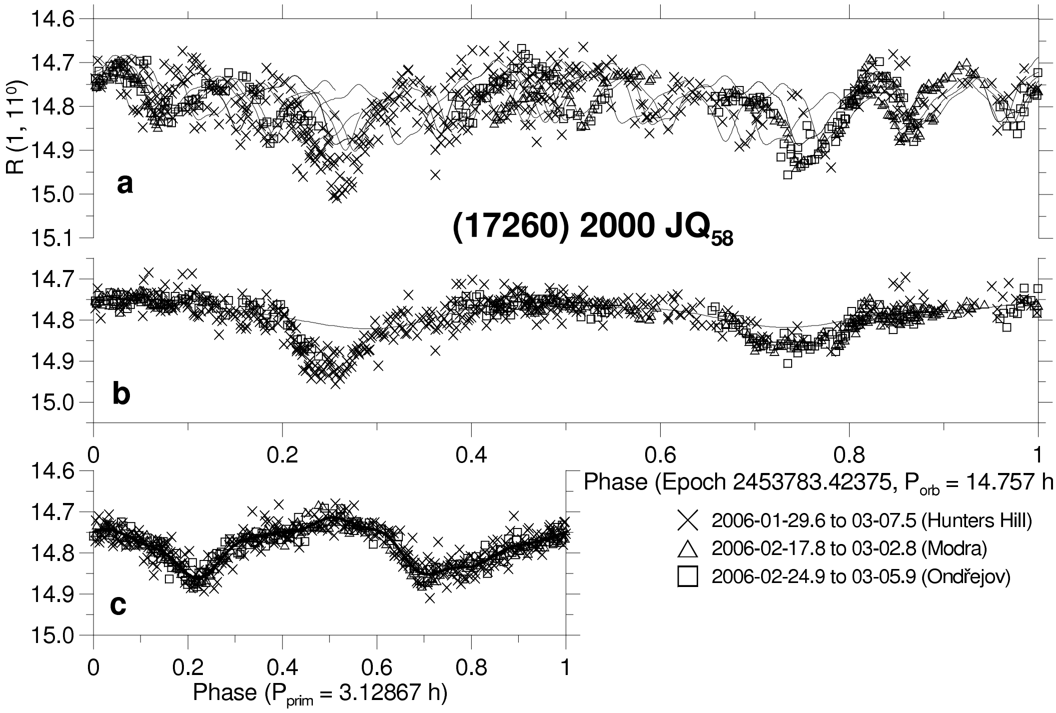


Suppl. Fig. 36. Lightcurve data of (9617) Grahamchapman from 2008. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

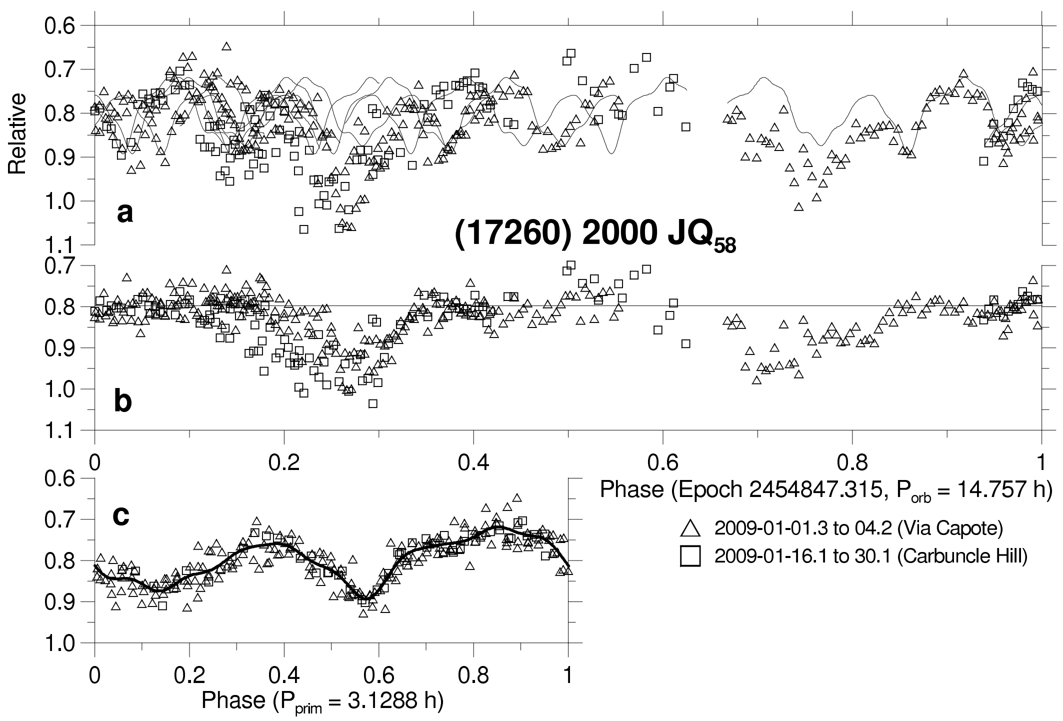
(17260) 2000 JQ$_{58}$

This binary was observed in two apparitions of 2006 and 2009. Our discovery announcement was Higgins et al. (2006b). In the discovery apparition, we got observations from Hunters Hill, Ondřejov and Modra on 11 nights from 2006-01-29.6 to 03-07.5. The data are shown in Suppl. Fig. 37. We estimated the primary period $P_1 = 3.12867 \pm 0.00006$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00013$ h) and amplitude $A_1 = 0.15$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01 mag. From these data we estimated the absolute magnitude $H_R = 14.09 \pm 0.10$ and slope parameter $G = 0.16 \pm 0.12$. A second rotation lightcurve component was also revealed and its period was estimated $P_2 = 14.745$ h (formal error 0.003 h). An apparent amplitude of the secondary lightcurve component, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.07$ mag. A flat bottom of the secondary event observed on 02-27.9 suggests that it was a total event. From its depth, we estimated the secondary-to-primary mean diameter ratio $D_2/D_1 = 0.26 \pm 0.03$.

In the second apparition, we got observations from Carbuncle Hill and Via Capote on 7 nights from 2009-01-01.3 to 30.1. The data are shown in Suppl. Fig. 38. We estimated the primary period $P_1 = 3.1288 \pm 0.0001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00025$ h) and amplitude $A_1 = 0.17$ mag.



Suppl. Fig. 37. Lightcurve data of (17260) 2000 JQ_{58} from 2006. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, shows the mutual events between components of the binary system and a rotational lightcurve of the secondary. (c) The primary lightcurve component.



Suppl. Fig. 38. Lightcurve data of (17260) 2000 JQ$_{58}$ from 2009. (a) The original data showing both lightcurve components, folded with the orbit period. (b) The orbital lightcurve component, derived after subtraction of the primary lightcurve component, showing the mutual events between components of the binary system. (c) The primary lightcurve component.

(76818) 2000 RG_{79}

We observed this binary in two apparitions of 2005 and 2008/2009. Our discovery announcement was Warner et al. (2005b). Our results, based on observations on 21 nights during 2005-08-07.3 and 09-15.3, were published in Warner et al. (2011). Four additional nights from Simeiz extended the interval up to 10-06.9. Our updated estimates for the primary period and amplitude are $P_1 = 3.16649 \pm 0.00003$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00015$ h) and $A_1 = 0.14$ mag. A second rotation lightcurve component was revealed and its period was estimated $P_2 = 14.127 \pm 0.002$ h ($\Delta P_{\mathrm{syn-sid}} = 0.003$ h). Its apparent amplitude, which is a secondary's amplitude in the combined total lightcurve of the system with the primary at its mean light, was $A_2 = 0.06$ mag. The Ondřejov R observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.01–0.015 mag. The Kharkiv R and V observations of 09-08.9 and 09.9 were calibrated in the Johnson-Cousins system using Landolt standards to an accuracy level of 0.02 and ~ 0.03 mag, respectively.

Observations in the second apparition, taken from Palmer Divide Observatory and GMARS during 2008-10-02.3 to 2009-01-03.2, were published in Warner and Stephens (2009). Additional sessions were taken from Carbuncle Hill, Ondřejov, Modra and Simeiz, they extended the observing period up to 2009-01-30.0. Our updated estimates for the primary period and amplitude obtained from analysis of the complete data from 39 nights are $P_1 = 3.16639 \pm 0.00001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.00026$ h) and $A_1 = 0.14$ mag. A period of the secondary lightcurve component was $P_2 = 14.128 \pm 0.001$ h ($\Delta P_{\mathrm{syn-sid}} = 0.005$ h) with the apparent amplitude $A_2 = 0.05$ mag. The Ondřejov observations were absolutely calibrated in the Cousins system using Landolt standards to an accuracy level of 0.02 mag.

From the calibrated data taken in the first apparition, we derived color index $V - R = 0.44 \pm 0.03$, the asteroid's absolute magnitude $H_R = 13.82 \pm 0.09$ ($H = 14.26 \pm 0.09$) and slope parameter $G = 0.45 \pm 0.10$. Assuming the same slope parameter, we estimated $H_R = 13.86 \pm 0.11$ in the second apparition.

From depth of the secondary events observed in the first apparition, we estimated a lower limit on the secondary-to-primary mean-diameter ratio of $D_2/D_1 = 0.35 \pm 0.02$. Data from the second apparition were noisier and they did not constrain the diameter ratio any more.

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