LOWELL OBSERVATORY NEAR-EARTH ASTEROID PHOTOMETRIC SURVEY (NEAPS): PAPER 5

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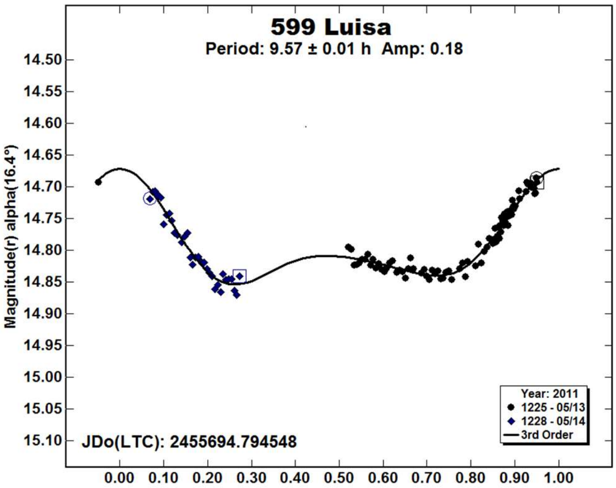
New photometry and lightcurves are shown for 107 asteroids observed mainly between 2009 and 2012 using four telescopes at Lowell Observatory. The data have not been previously published in detail. This completes work on the NEAPS program.

Previous reports in this series (Skiff et al., 2019a, Paper 3; Skiff et al., 2019b, Paper 4) gave revised or new results for more than 200 asteroids observed mainly at the end of a 12-year project to discover and characterize NEOs (Koehn and Bowell, 2000). The present work completes the NEAPS program, covering an especially concentrated period of observing 2009-2012. The same four Lowell Observatory telescopes were involved as described previously, and the personnel also the same. The two workhorse instruments were the 0.55-m *f*/1.9 LONEOS Schmidt (MPC observatory code 699) and robotic 0.7-m *f*/8 reflector (code 688 for this and other Lowell telescopes located at its Anderson Mesa site). The Schmidt was operated unfiltered, while the 0.7-m was used with an R_c filter. Both telescopes are now closed. In addition, the 1.1-m *f*/8 Hall and 1.8-m Perkins reflectors were occasionally employed. Further details about the instrumentation, data-acquisition, and reductions can be found in the previous papers.

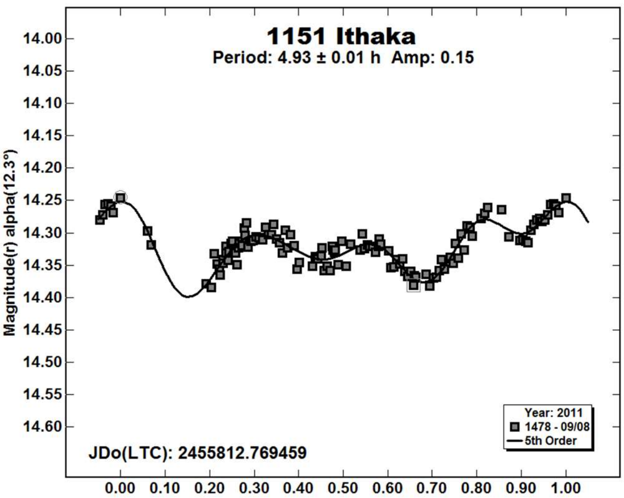
Following image-preparation (bias correction and flat-fielding) using local software, all the data have been reduced through *MPO Canopus*, and adjusted as well as possible to the standard Sloan r′ system using improved photometry for the comparison stars. These were tied largely to the Pan-STARRS survey catalogue (Magnier et al., 2016). No color transformations were involved, only zero-point adjustment to asteroidal-color reference stars. These are preferably G/K dwarfs somewhat redder than the Sun. The phased lightcurves show apparent magnitudes reckoned from the first night by *MPO Canopus*. The primary maximum is set to phase zero in order to make it convenient to compare lightcurve morphologies at different apparitions or viewing geometries. The lightcurves shown below for (47035) 1998 WS are an example of this.

In preparing these results, the LCDB (Warner et al., 2009) was queried in 2022 Aug. Some of our lightcurves were previously posted to the CALL site; the results here supersede those interim reports, and are not mentioned unless necessary.

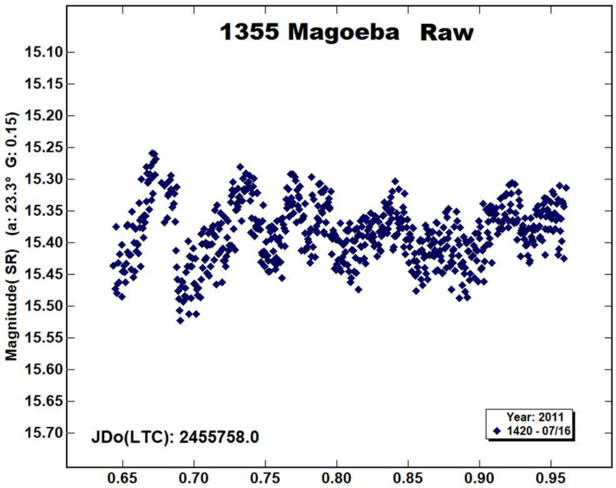
599 Luisa. Despite having only two relatively short runs on this main-belt asteroid in 2011 May, there is enough curvature to fit our incomplete 0.7-m data with the period first found by Debehogne et al. (1977). The RMS scatter is 0.010 mag.



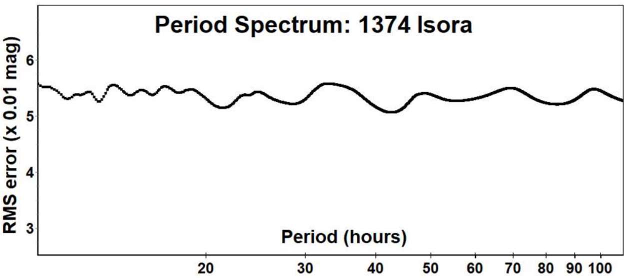
1151 Ithaka. At least three other observers besides ourselves got lightcurves for this main-belt object in 2011 Aug-Sep (Aymami, 2012; Franco et al., 2012; Pravec, 2011web). Everyone agrees on the period and that the asteroid exhibited a quadrimodal lightcurve at that apparition. We contribute data taken with the Schmidt for about seven hours on 2011 Sep 8 using 8-second exposures. After averaging the data into three-image 2-minute bins, the RMS scatter is 0.013 mag.

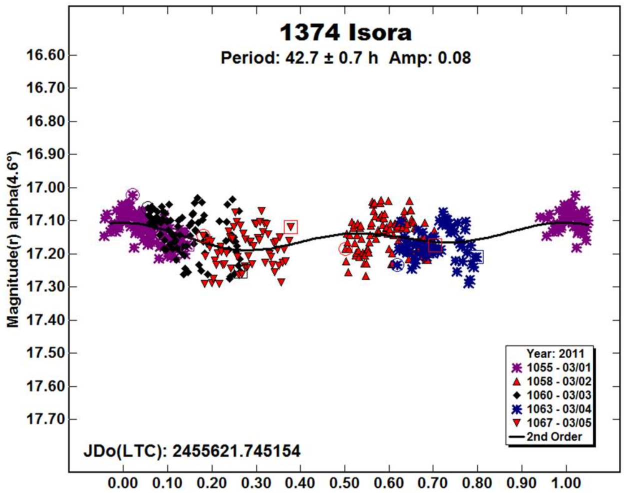


1355 Magoeba. There is obviously small-amplitude cyclic variation on a short timescale in this Hungaria, but our single-night 7-hour Schmidt run in 2011 Jul is insufficient to say much beyond that. The five comparison stars are constant with RMS scatter averaging only 0.009 mag Various periods near 3, 6, and 32 hours have been suggested (e.g., Warner, 2010; Stephens and Warner, 2020).

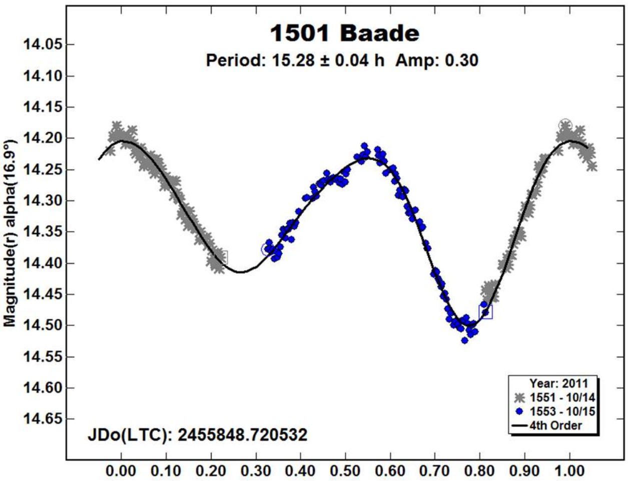


1374 Isora. Five consecutive nights in 2011 Mar using the 0.7-m telescope were inadequate to define the small amplitude lightcurve of this Mars-crosser. Stephens (2014) gave a tentative period of 37 h. Our data are too uncertain to confirm this, but a phased lightcurve at a very weak minimum in the periodogram near it is shown, likely merely coincidental. The RMS scatter of this fit is 0.05 mag.





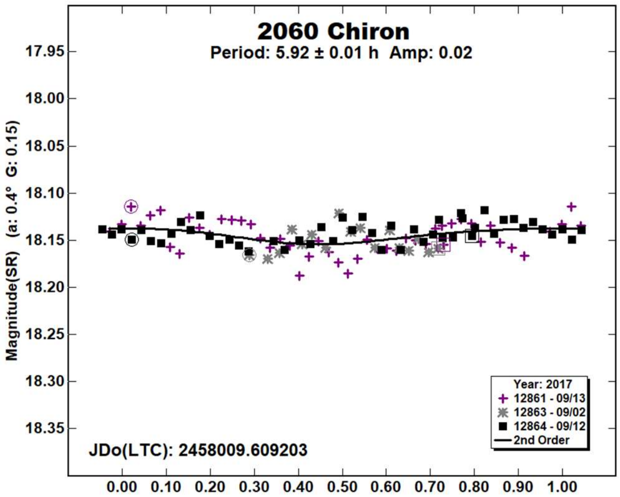
1501 Baade. Two nights on this main-belt asteroid using the 0.7-m telescope in 2011 Oct do not quite give complete rotational phase coverage, but the period is reasonably well-defined. As early as 2003 Oct, Ivarsen et al. (2004) determined a similar period. At about the same time, Maleszewski and Clark (2004) seem to have found a 10-hour 2:3 alias. The RMS scatter on the fit to our data is 0.011 mag.



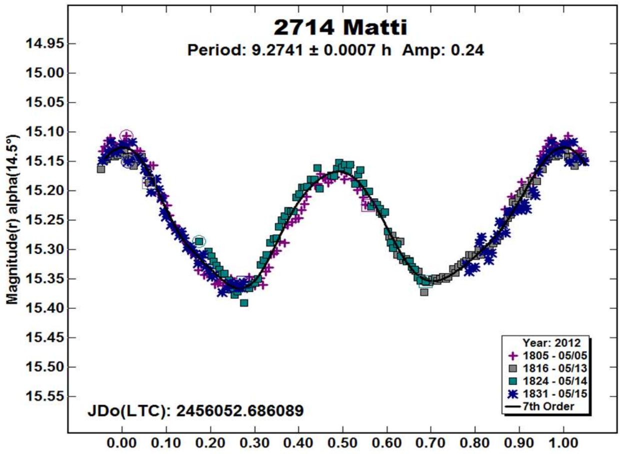
2060 = 95P Chiron. The earliest lightcurve of the first known Centaur was by Bus et al. (1989), who found the rotation period near 5.9 h, mainly from 1.8-m Perkins telescope CCD data taken in 1986 Nov-Dec. A few years later, Bus et al. (1991) identified cometary CN emission in spectra taken with the same telescope. In 2009 Nov, as part of monitoring the object for possible cometary activity, we obtained five 3-minute exposures on two nights using the Schmidt. These adjust to Sloan r′ mag 17.92 ± 0.03 (UT 2009 Nov 20.1) and 17.97 ± 0.03 (UT 2009 Nov 21.1).

We also attempted to get a complete lightcurve in 2017 Sep, again using the 1.8-m telescope. This was not entirely successful partly due to poor weather, and also the very small lightcurve amplitude at the time. A phased plot is shown here with the 150-second exposures binned into three-image 8-minute averages. The RMS scatter on the order-2 fit is 0.014 mag.

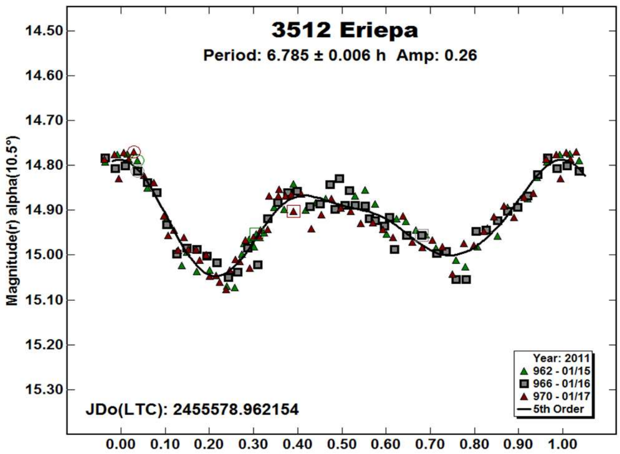
Perhaps due to the very small amplitude, the last high-precision lightcurve was obtained in 1996 by Lazzaro et al. (1997).



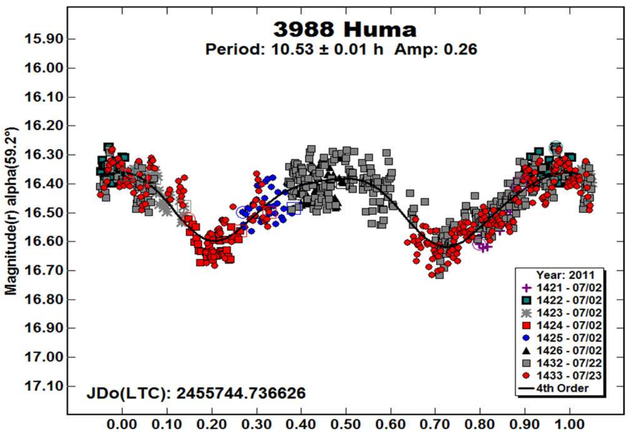
2714 Matti. Wisniewski et al. (1997) published a preliminary period of 9 ± 2 hours for this main-belt Flora. From four nights of 0.7-m data in 2012 May, we refine this to 9.27 hours. The RMS scatter on the fit is 0.012 mag with three-image 4-minute averaging**.**



3512 Eriepa. This ordinary main-belt asteroid was discovered by then-MIT student Joe Wagner in 1984 Jan on Lowell "Pluto Camera" plates. Ditteon et al. (2004) first determined the rotation period. Three nights of photometry using the 0.7-m telescope in 2011 Jan yielded a smooth lightcurve of moderate amplitude. The RMS scatter from the 90-second exposures is 0.026 mag. The morphology is quite distinct from the earlier result since the PAB longitude and phase-angle are quite a bit different.

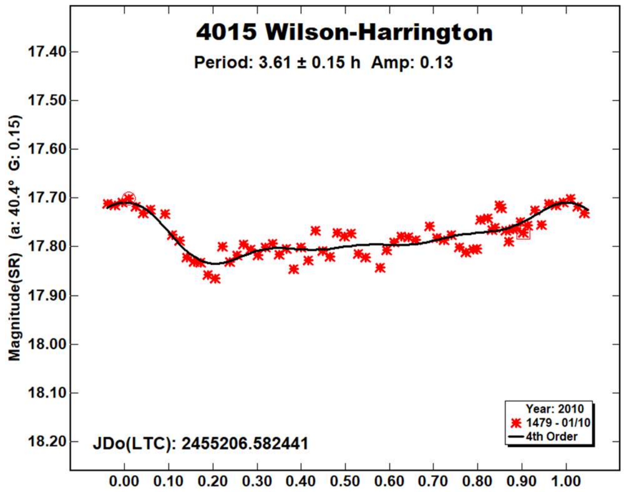


3988 Huma. Our data for this Amor were taken on 2011 Jul 2 using the 0.7-m telescope (R_c filter), then Jul 22 and 23 using the Schmidt (unfiltered). The results are noisy but yield a first look at the rotation period. The RMS scatter is 0.05 mag.

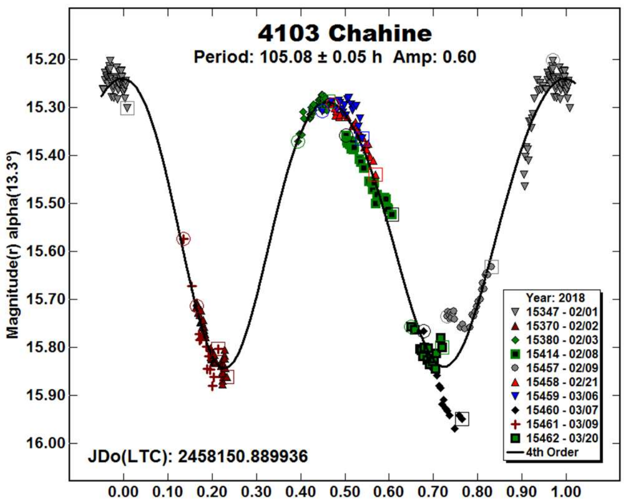


4015 = 107P Wilson-Harrington. This Apollo-type NEO was discovered as a faint comet on 1.2-m Schmidt plates taken in the early days of the first Palomar Observatory Sky Survey, but subsequently lost. It was rediscovered as 1979 VA by "Glo" Helin, also at Palomar. Though well-observed at that apparition, no cometary activity was noticed. The identification of the two objects was made by Ted Bowell while tracing 1979 VA back to the 1949 POSS prints, and the linkage made by Brian Marsden (Marsden, 1992). Cometary activity has not been observed since.

We made several attempts to get a lightcurve using the Schmidt during 2009, but none was satisfactory. We show results from a single 4-hour run in 2010 Jan using the 1.1-m telescope. The derived period is somewhat shorter than the series itself, so is provisional. However, Harris and Young (1983) and Urakawa et al. (2011) found periods of 3.56 and 3.57 hours, respectively, well within our formal uncertainty. The RMS scatter on the fitted curve is 0.023 mag.

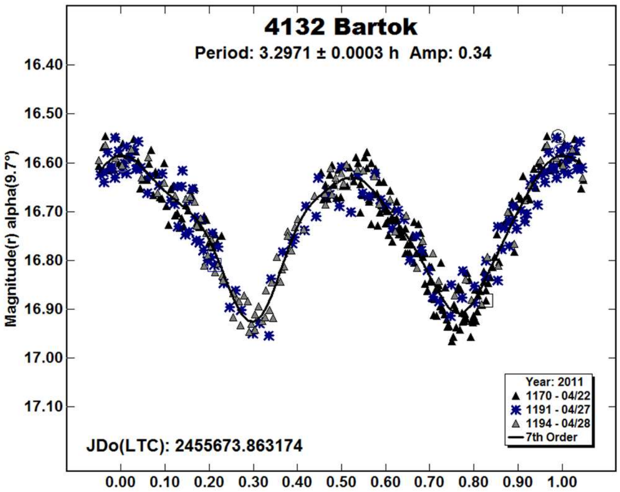


4103 Chahine. A series covering several weeks in 2018 Feb-Mar was obtained for this Phocaea using the 0.7-m telescope with 4- and 5-minute exposures. These produced a long-period lightcurve having significant tumbling aspect.

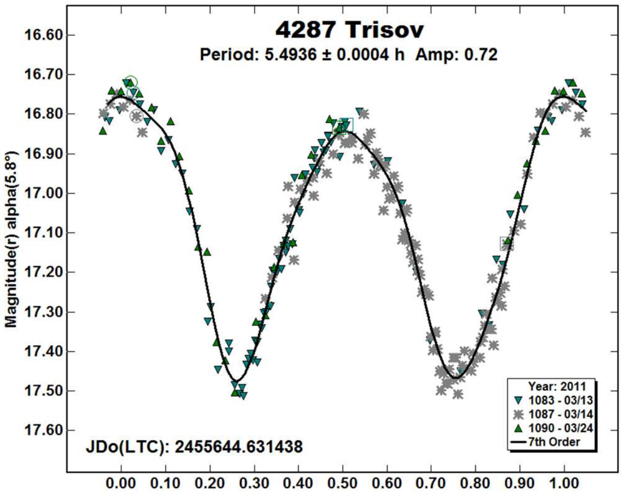


The period shown matches very nearly the one derived from TESS data by Pál et al. (2020), where the tumbling component was overlooked. Similar results from an apparition in late 2020 have been given by Polakis (2021) and Owings (2021). The RMS scatter is 0.035 mag, but this results from the incomplete model fit; the nightly internal errors are better. We include in the database three isolated nights from 2011 using the Schmidt; these show only the broad nightly trends.

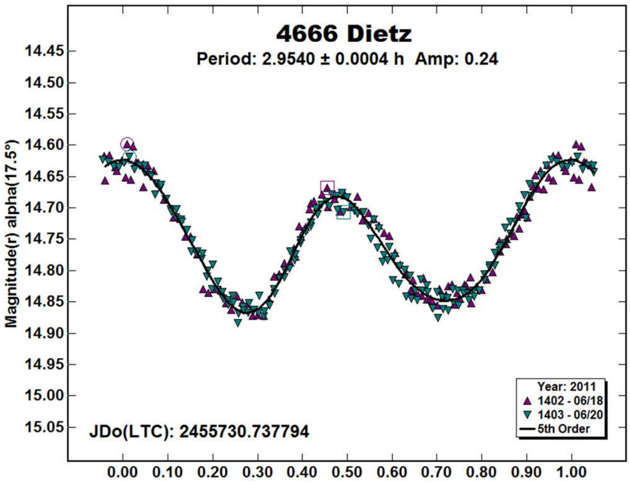
4132 Bartok. Now a much-observed Phocaea, we got three nights on this asteroid in 2011 Apr using both the Schmidt (unfiltered) and 0.7-m telescope (R_c filter). Almost 20 hours were spent on-target and a total of 400 frames acquired. The period is very close to subsequent determinations (e.g., Warner, 2014b); the RMS scatter on the fit is 0.032 mag.



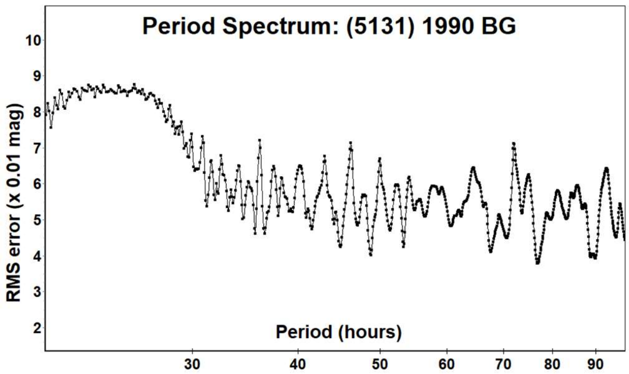
4287 Trisov. This main-belt Flora has a previously published period from ATLAS survey data by Ďurech et al (2020). Three nights of 0.7-m telescope data in 2011 Mar, including a ten-day gap, allow the rotation period to be determined accurately. The RMS scatter is 0.04 mag.

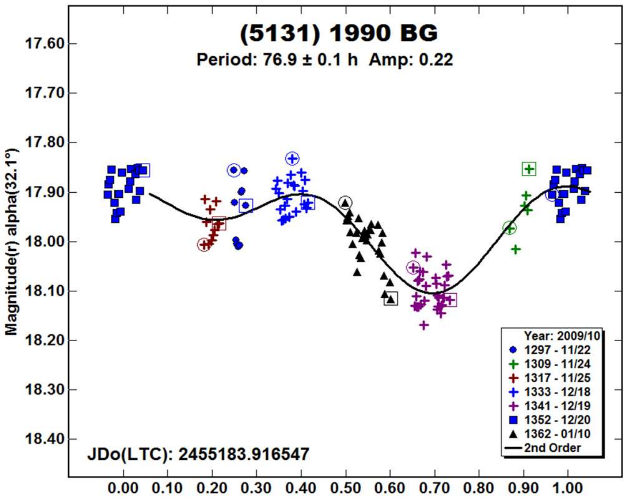


4666 Dietz. Several groups besides ourselves observed this Phocaea during 2011 Jun (e.g., Ferro, 2011). The object was later found to be binary or triple with mutual events (Oey et al., 2018). Our two nights of Schmidt data show no evidence of this. The RMS scatter on the fit is 0.014 mag after averaging the 12- and 15-second exposures in three-image 3-minute bins.

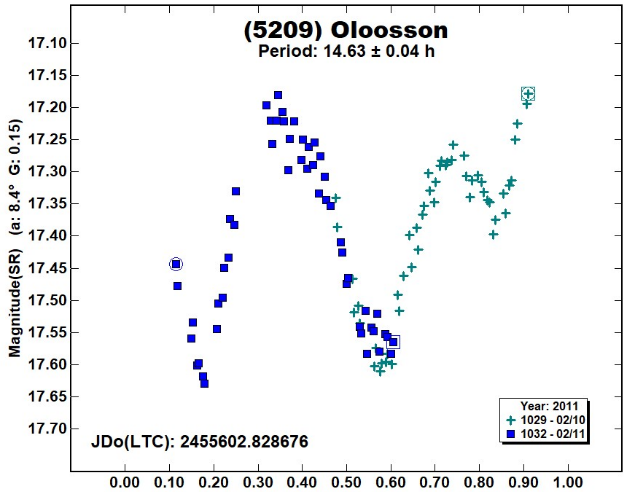


(5131) 1990 BG. Warner (2015) published a rotation period of 20.9 h for this Apollo, later modified in the LCDB to 37.2 ± 0.5 h, obviously uncertain. Our Schmidt data from 2009 Nov-2010 Jan also suggest a slow rotation roughly at double the revised Warner value. The asteroid was quite faint, so our data are likewise uncertain. The RMS scatter is 0.04 mag.

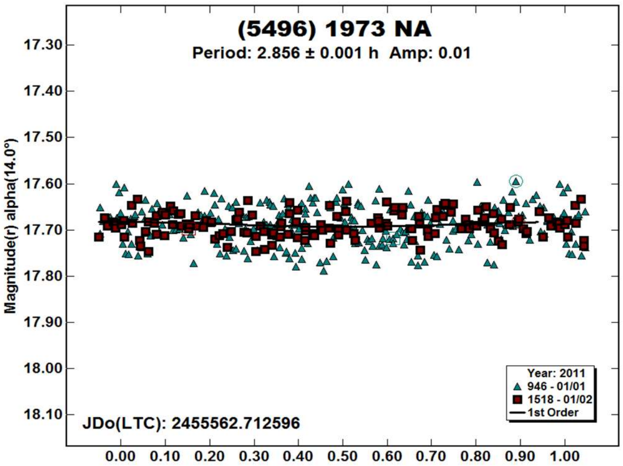


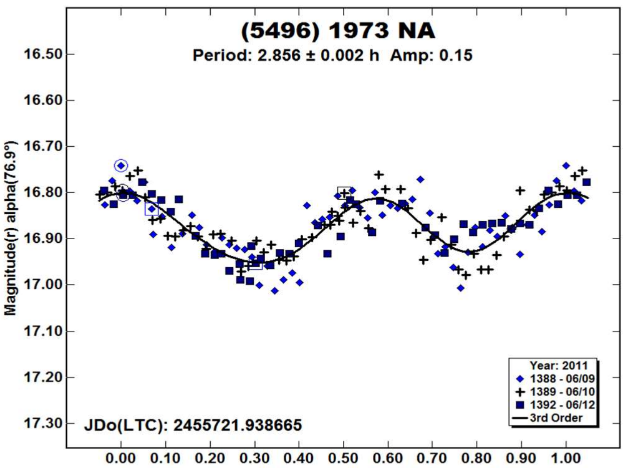


5209 Oloosson. Unfortunately, we devoted only two nights to this Jupiter Trojan using the 0.7-m telescope in 2011 Feb. The period is long enough that we obtained only partial lightcurve coverage. The fit shown here merely lets the two nights of data phase together without forcing. The RMS scatter is 0.025 mag. There is no photometry shown in the LCDB.



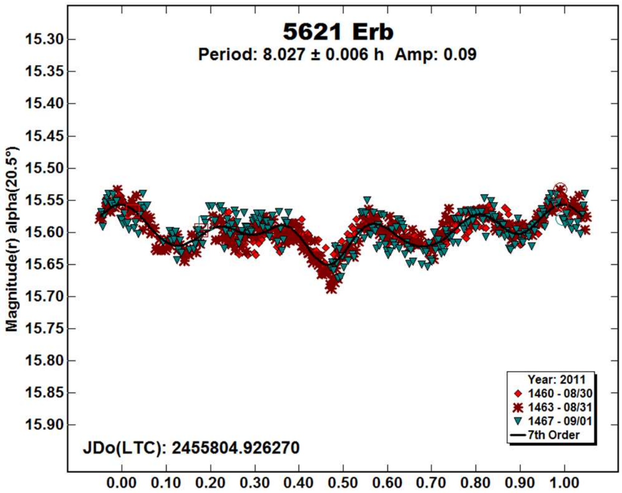
(5496) 1973 NA. Our first attempt on this asteroid was on 2011 Jan New Year's Eve and New Year's night, when we obtained data using the Schmidt and the 1.1-m telescope. Remarkably, but disappointingly, the 15-hour combined dataset showed a completely flat lightcurve. It didn't help that it was 1.3 mag fainter than the initial prediction. Six months later the asteroid was at high phase-angle, and we tried again on three nights using the Schmidt. This produced a short-period lightcurve of modest amplitude. The two series are displayed below.



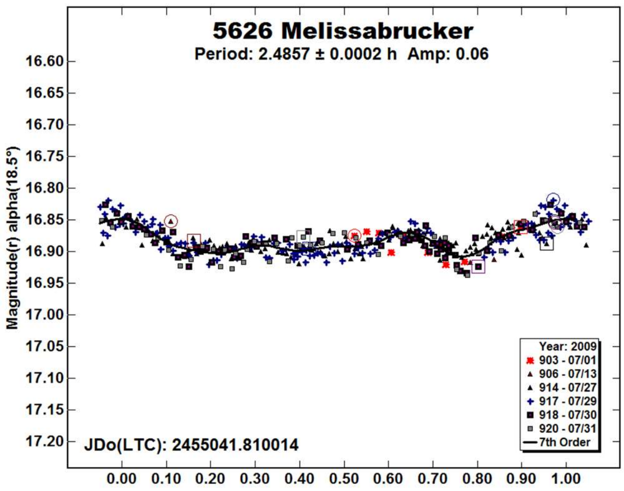


The 2011 Jan plot shows the data force-fit to the period determined in the second run. The RMS scatter is 0.037 mag, so any variation was less than one-third the noise level. The second lightcurve is plotted at the same vertical scale, and has RMS scatter of 0.034 mag following averaging the data into three-image 4-minute bins. This Apollo has been mostly fainter than mag 19 since 2011, so there is no other published photometry.

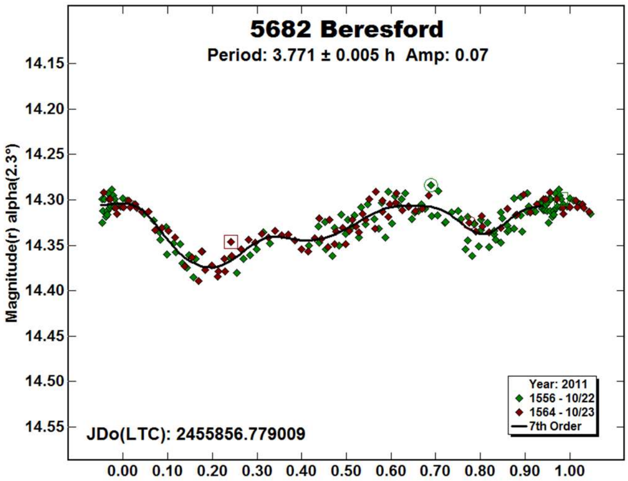
5621 Erb. These data are apparently the only lightcurve photometry available for this Mars-crosser. We observed it on three nights at the end of 2011 Aug using the 0.7-m telescope and 90-second exposures. The lightcurve has small amplitude and quadrimodal form. The RMS scatter on the fit is 0.015 mag.



5626 Melissabrucker. We obtained data for this Amor spanning five months in 2009 using the Schmidt. Only the data from 2009 Jul are useful for characterizing the small-amplitude lightcurve. The asteroid brightened from Sloan r′ mag 16.9 up to 15.5 through the month, and exposures were gradually reduced from 90 to 45 seconds. The results confirm the most recent period determinations by Warner and Stephens (2020) from their 2020 Feb and revised 2019 lightcurve data. Note that the morphology of their 2020 Feb lightcurve is identical to the one shown here, which was done at PAB longitude very nearly 180° away. The present data have RMS scatter of 0.013 mag, as good as the best previous data.

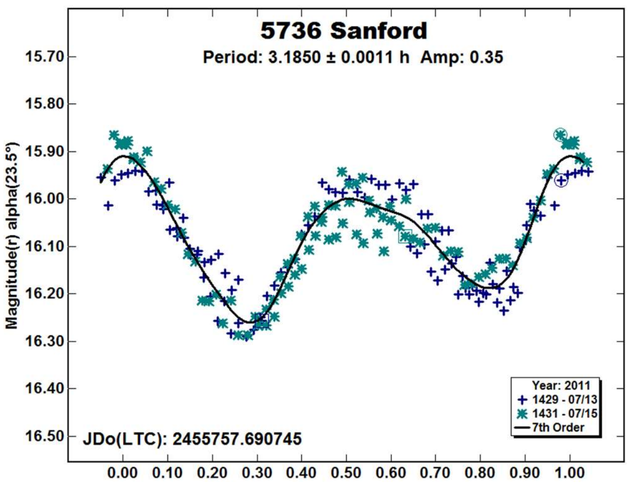


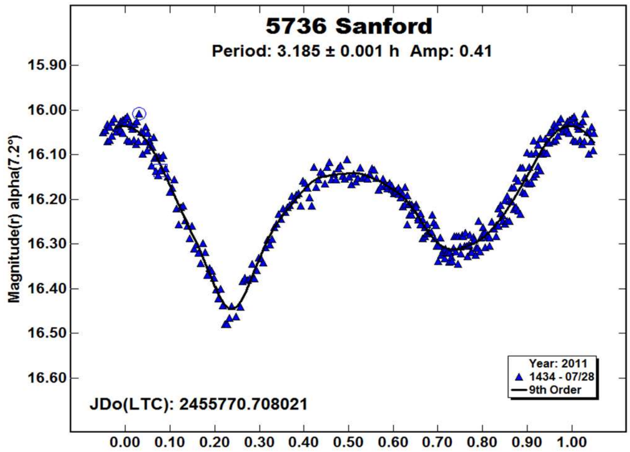
5682 Beresford. Two previous photometric studies have been published for this Mars-crosser. Kamél (1998) was not able to determine a period from data taken in autumn 1997, probably due to the small lightcurve amplitude. In 2004 Koff (2005) found a period of about 7.5 hours from somewhat noisy data. Benishek (2022) concluded that the half-period was preferred, but suggested some ambiguity remained. From our two nights of 0.7-m data in 2011 Oct, including an 8.4-hour run the first night, we also find a better fit to the shorter period, though we agree the longer one is not utterly excluded. The RMS scatter on the fit is 0.011 mag.



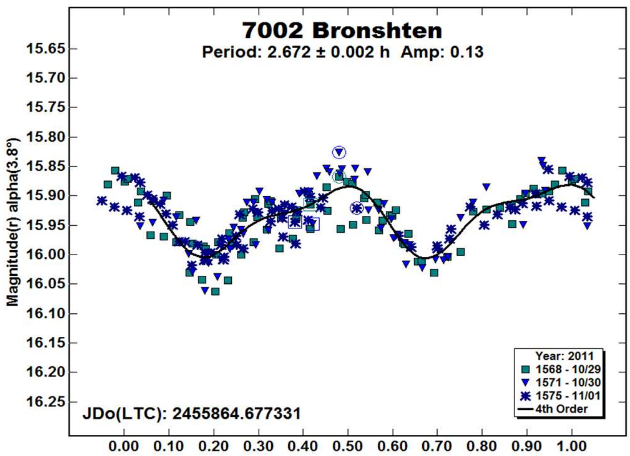
5736 Sanford. The only previously available lightcurves for this Phocaea are those of Pravec et al. (Pravec, 2011web), which were done in summer of 2011. We also obtained three nights at Full Moon in 2011 Jul using the Schmidt.

Two of these were satisfactory, and are shown in the first phased plot below. The data are binned into four-image 3-minute averages; the RMS scatter is 0.038 mag Our period matches that of Pravec et al. Another Schmidt night two weeks later without Moonlight (and smaller phase-angle) gave much better results. We fit the data in the 4.7-hour run to the previously determined period. The RMS here is 0.021 mag with no binning.

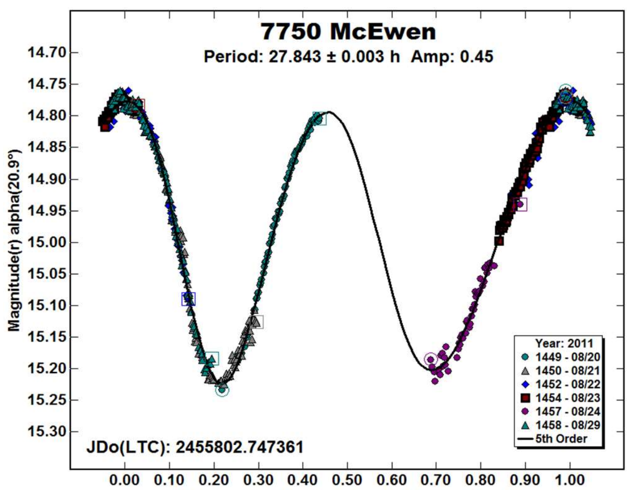




7002 Bronshten. Warner and Stephens (2019) showed that this Mars-crosser was a binary with a relatively short secondary orbital period. Our 0.7-m telescope data on three nights in 2011 Oct (about 8 hours each night) are more scattered than expected, so likely exhibit some distortion from modest tumbling or mutual events. The phased plot shows only the short period of the primary component; the RMS scatter is 0.027 mag, which includes the scatter from the secondary period.

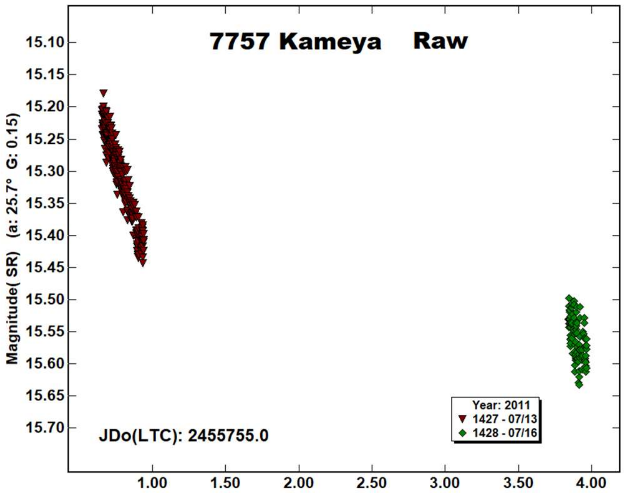


7750 McEwen. The first published of several studies obtained in 2011 for this asteroid was by Lee Owings (2012).

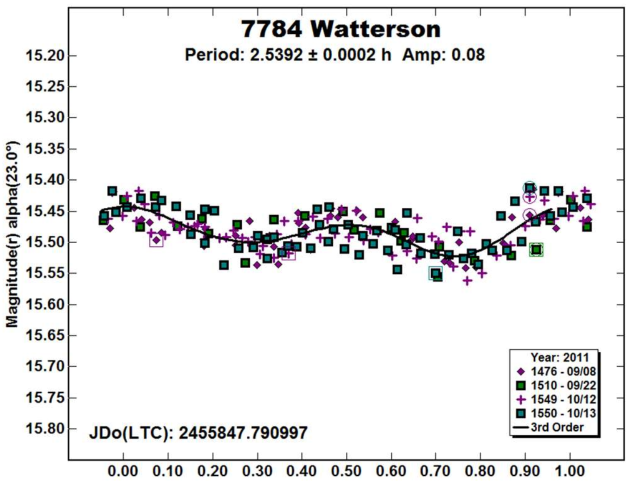


The main-belt object has a moderately-long rotation period and smooth lightcurve. Our series was done 2011 Aug using the 0.7-m telescope during a break in the Arizona summer monsoon, and we lack complete rotational phase coverage. The RMS scatter on the fit is 0.011 mag.

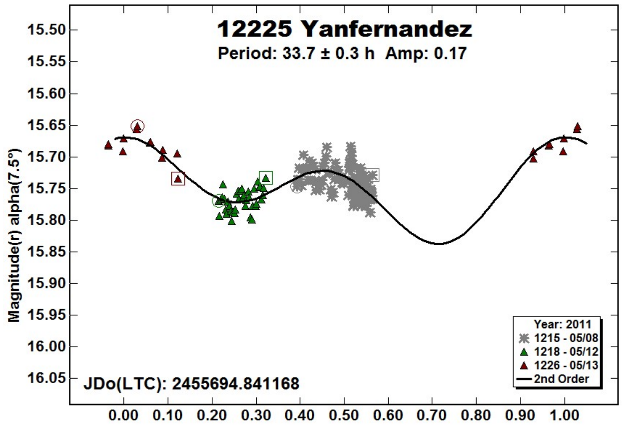
7757 Kameya. Warner (2005) published the only previous data on this Phocaea, showing an ambiguous period near 6 h. However, the first of our two 2011 Jul nights on the target spans 6.8 h, yet there is only a monotonic decline in brightness. The additional partial night three days later has a similar slope. The data comprise about three-hundred eighty 1-minute exposures using the 0.7-m telescope. A period of many tens of hours is indicated.



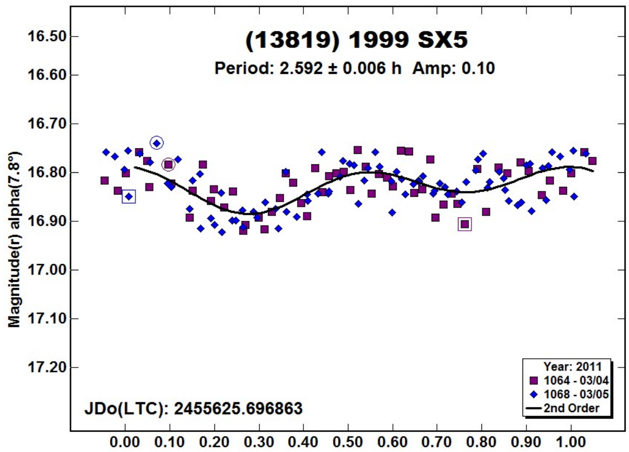
7784 Watterson. Our four nights for this Phocaea span more than a month in 2011 Sep-Oct. The 0.7-m telescope was used with 90-second exposures throughout. The data are highly consistent and no zero-point adjustments were needed. The phased plot shows the data averaged into three-image 5-minute bins. The RMS scatter is 0.024 mag. Benishek (2022) finds that a period near 5 h is preferred in his data, but fitting our data to that period gives significantly larger residuals. Because of the fairly small amplitude, a series with better internal errors will be required to resolve the uncertainty.



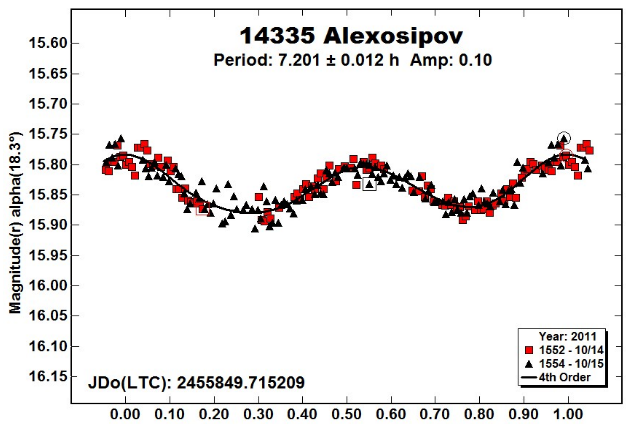
12225 Yanfernandez. Three nights of data in 2011 May using the 0.7-m telescope on this main-belt Flora show only slow variations. The fit here is probably indicative of a period of some tens of hours. The notional RMS scatter is 0.018 mag.



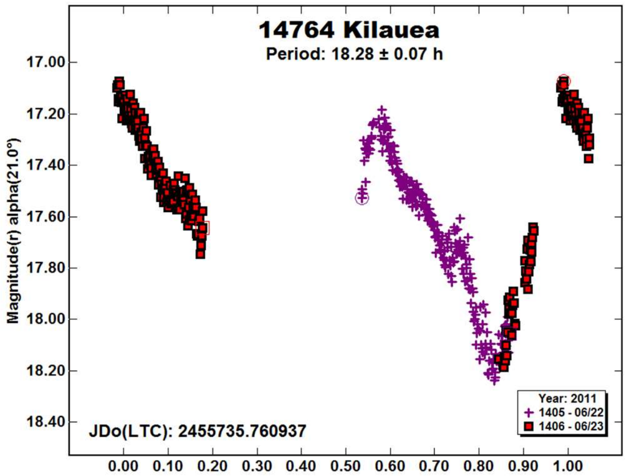
(13819) 1999 SX5. Two nights in 2011 Mar on this 4-km Mars-crosser showed only small variation relative to the noise in 0.7-m telescope data. The period fit is uncertain since the full amplitude is barely at the 3-sigma level. The RMS scatter is 0.035 mag. Behrend (2020web) shows data phased to a very similar period.



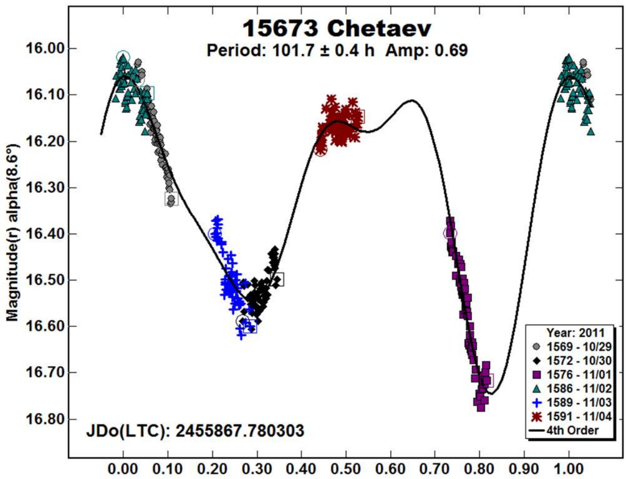
14335 Alexosipov. We observed this main-belt Flora on two nights in 2011 Oct using the 0.7-m telescope. The period is quite certain, matching that from TESS data (Pál et al., 2020) within errors, but with different PAB longitude; the amplitude here is much smaller. The RMS scatter on the fit is 0.014 mag.



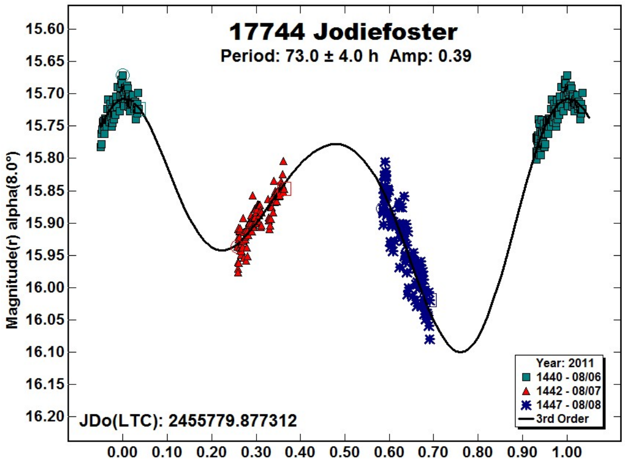
14764 Kilauea. Our two 2011 Jun solstice nights using the Schmidt were insufficient to cover the fairly long periods of this Hungaria, now known to be tumbling (Warner et al., 2012b). The lightcurve shows a notional fit to the data, but this is *not* the rotation period.



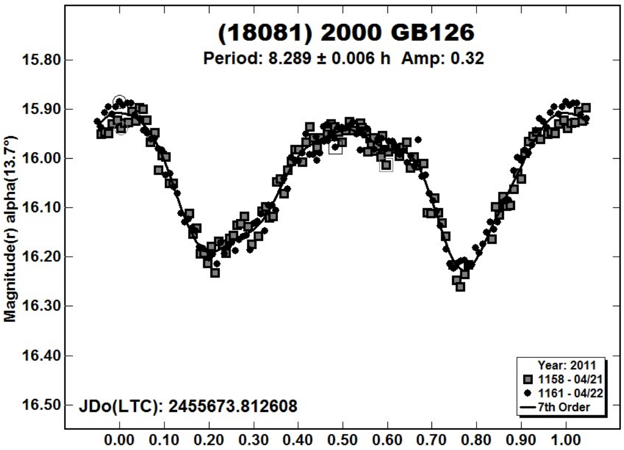
15673 Chetaev. This Mars-crosser has no previous lightcurve study. On six of seven consecutive nights in 2011 Oct-Nov we got runs of about 8 hours duration using the 0.7-m telescope. These were sufficient only to outline the variation approximately. The period is of order 100 hours with fairly large amplitude. We do not really have enough coverage to say whether or not there is tumbling, which might be expected. The RMS scatter on the fit is 0.030 mag.



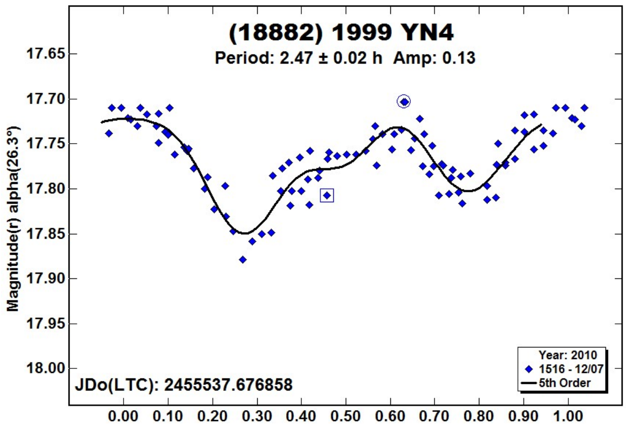
17744 Jodiefoster. Three nights in 2011 Aug using the 0.7-m telescope allowed us to find that the period of this Mars-crosser is relatively long, many tens of hours. The fit shown here is tentative only; the RMS scatter is 0.021 mag.

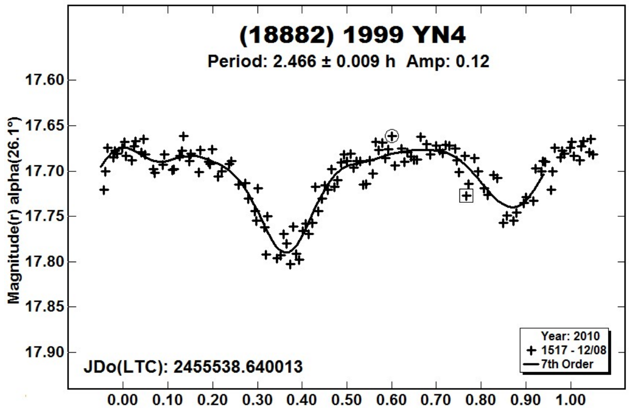


(18081) 2000 GB126. Two nights were spent on this Phocaea in 2011 Apr using the 0.7-m telescope; each run of 90-second exposures extended beyond 8½ hours. The lightcurve is well defined, with RMS scatter on the fit of 0.019 mag.



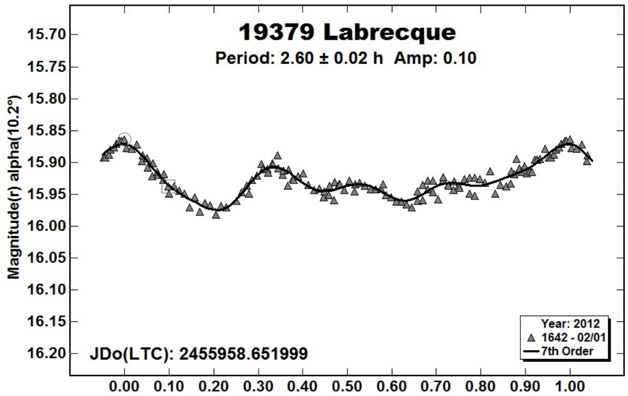
(18882) 1999 YN4. The LCDB shows no photometry for this Amor. We obtained two nights of 1.1-m telescope data in 2010 Dec. The (better) second night shows an ordinary short-period lightcurve. The previous night is somewhat less good, and we are unable to tell whether there is some problem with the data or if there is an indication of weak tumbling or a dimming event. A binary companion would not be unexpected in this period range.



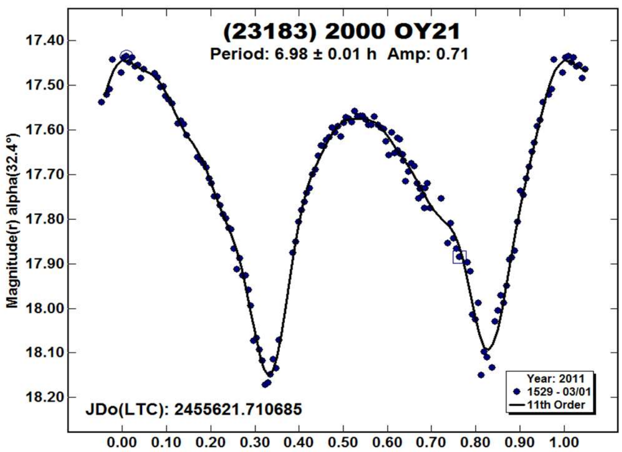


We show phased plots separately for the two nights. The RMS scatter is 0.018 mag for Dec 7, and 0.013 mag for Dec 8. Warner and Stephens (2022b) give a period of 2.35 h from somewhat noisier data (RMS ~0.03 mag).

19379 Labrecque. Using data from René Roy, Behrend (2007web) gave a provisional period of 8.3 h for this Phocaea. Our single 4.5-hour run using the 1.1-m telescope in 2012 Feb shows a period of only 2.6 h. It is reasonable to be skeptical, though there is repeat coverage between phases 0.7 and 0.1, as shown below, so the period seems secure, if imprecise. The RMS scatter is 0.009 mag versus ~0.05 mag for the Behrend data.

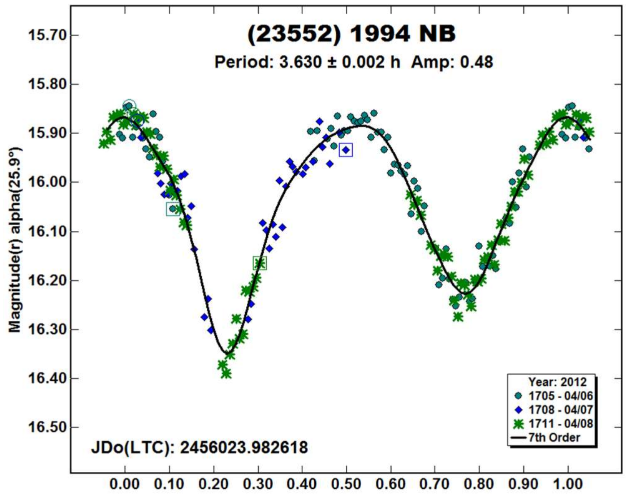


(23183) 2000 OY21. These data for this 1-km Amor were overlooked for our Paper 4 (Skiff et al., 2019b), which shows three nights taken one month prior.

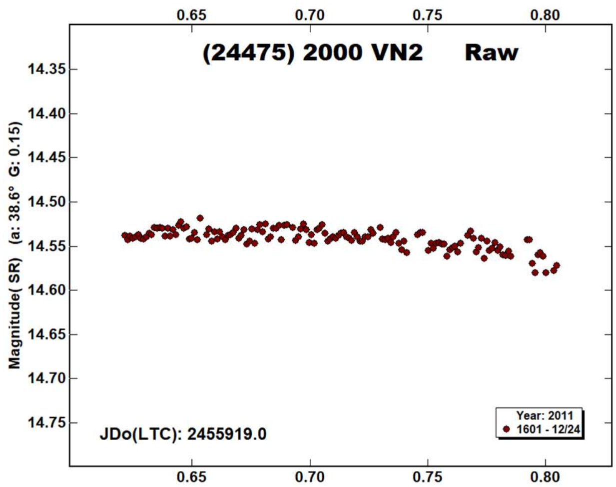


An 8-hour run on 2011 Mar 1 using the 1.1-m telescope fits the Paper 4 period (also cf. Warner, 2016b). The RMS scatter is 0.021 mag, about the same as the earlier data, but the asteroid was more than 1.5 mag fainter. The slight jog near phase 0.7, which seemed anomalous in our previous lightcurve, is present here also.

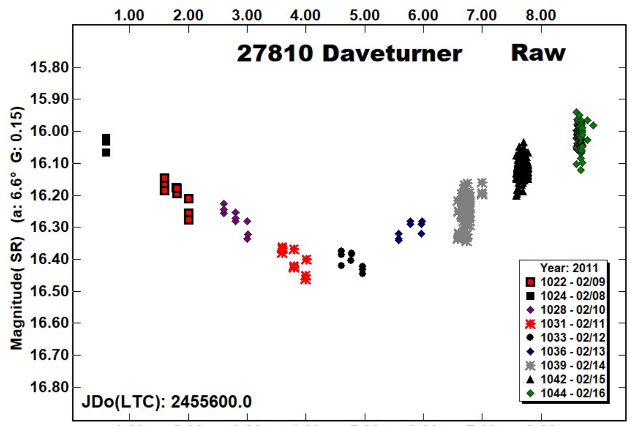
(23552) 1994 NB. Two wide-field surveys have produced rotation periods for this Phocaea: Waszczak et al. (2015) using Palomar Transient Factory data and Pál et al. (2020) from the TESS spacecraft. Both yield periods similar to ours, which is from 0.7-m telescope data in 2012 Apr (the same date-range as the PTF result). The RMS scatter on the fit is 0.029 mag.



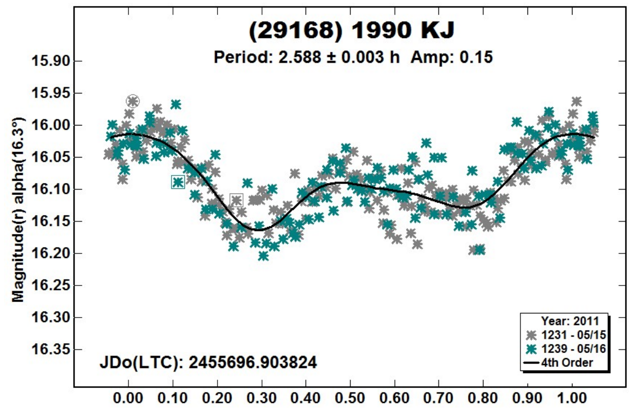
(24475) 2000 VN2. Without saying so explicitly, Melton et al. (2012) saw only a small variation in brightness in this Amor. We got a single night using the 0.7-m telescope in 2011 Dec, which we show to give an indication of the range and that the period must indeed be very long, many tens of hours. The RMS scatter on the trend is about 0.007 mag. The asteroid has not been observed otherwise.



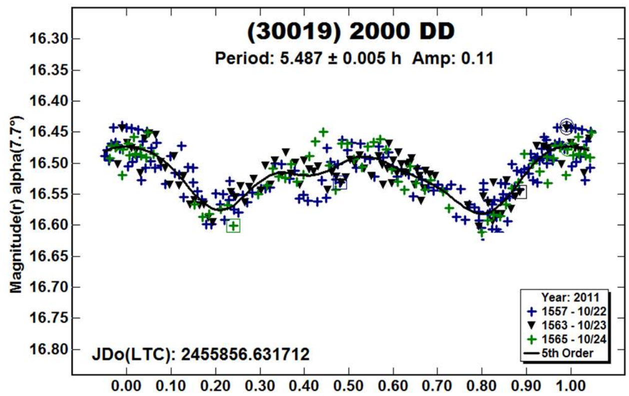
27810 Daveturner. The very long period of this Hungaria was described by Warner et al. (2011), which includes the series shown below. Sparse observations were obtained on nine consecutive nights in 2011 Feb using the 0.7-m telescope. A raw plot, now adjusted to Sloan r′ mags, traces the very slow, smooth variation over the interval.



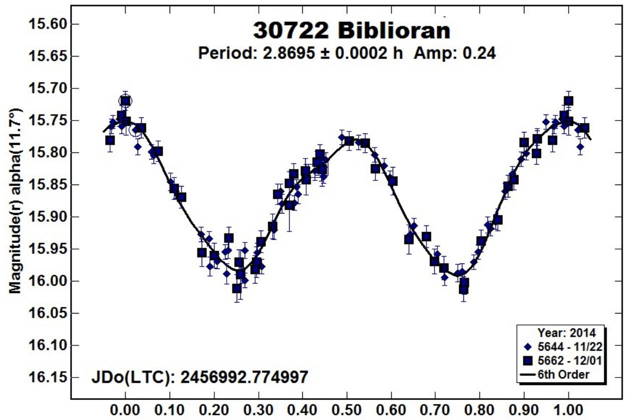
(29168) 1990 KJ. Pravec (2011web) found this Phocaea to be binary from extensive observations taken during the same 2011 apparition as we observed. Our data are more limited in time and have much lower precision. We show a lightcurve fit to Schmidt data with the 15- and 20-second exposures averaged into three-image 3-minute bins. The RMS scatter is 0.031 mag.



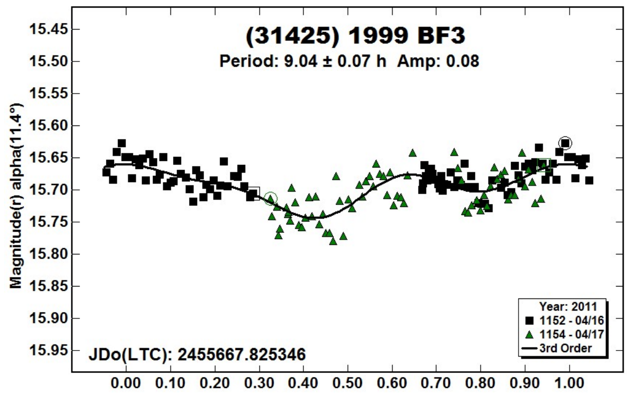
(30019) 2000 DD. Brian Warner (2012a) obtained the first correct rotation period for this Hungaria, including a revision of his earlier 2006 data. Our three nights in 2011 Oct using the 0.7-m telescope allowed us to find the same period within errors. The RMS scatter on the fit is 0.022 mag.



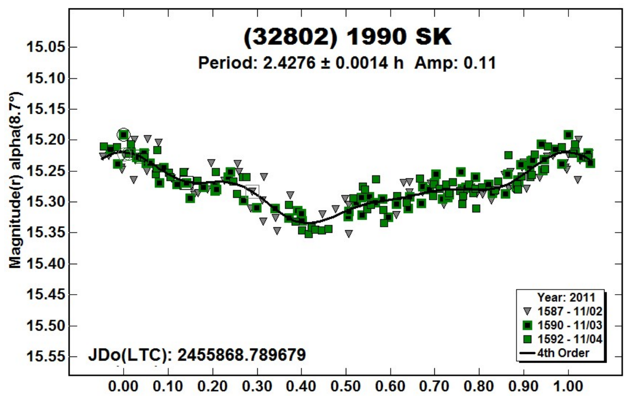
30722 Biblioran. Two long nights using the 0.7-m telescope in 2014 Nov each sparsely covered more than three rotations of this main-belt asteroid. The lightcurve is well-defined, with RMS scatter of 0.016 mag.



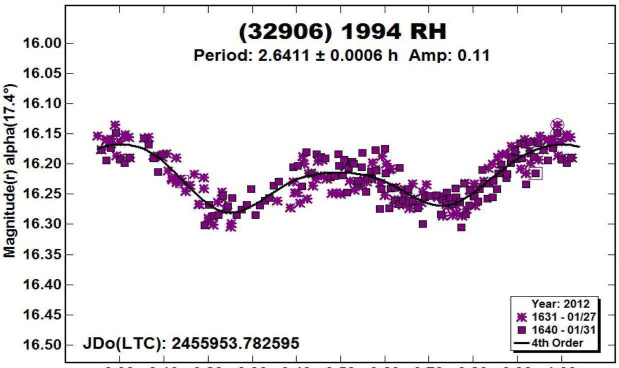
(31425) 1999 BF3. Previously (Skiff, 2011web) we used the data here to suggest a period of 5.9 h for this main-belt asteroid, assigned a rating of U = 1+ in the LCDB. The observations were taken in 2011 Apr with the 0.7-m telescope, and are now adjusted more closely to Sloan r´ mags. Re-examination of the data suggests a longer period by a 3:2 ratio, but with only two nights, there is the possibility that we simply have not covered the entire rotation cycle of the small-amplitude lightcurve (i.e., reliability still U = 1+ or 2-). The RMS scatter on the fit is 0.022 mag.



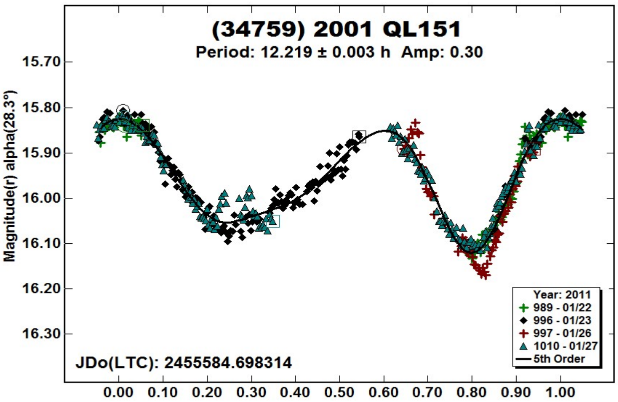
(32802) 1990 SK. This Phocaea turned out to have a short period. Three consecutive nights of 8-hour runs using the 0.7-m telescope in 2011 Nov allowed the variations to be well defined thanks to covering more than three rotational cycles each night. The RMS scatter on the fit is 0.017 mag.



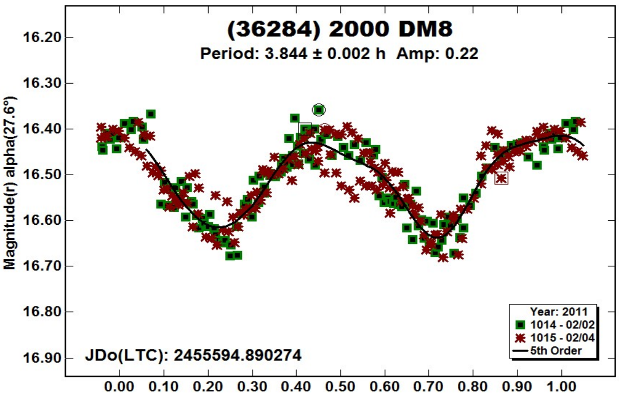
(32906) 1994 RH. Despite some clouds, we got more than one rotational cycle of observations on this Amor using the 0.7-m telescope on two nights in 2012 Jan. The lightcurve has a short period and moderately-small amplitude. The RMS scatter on the fit is 0.020 mag. We covered about 1.5 cycles each night, so the period was evident from visual inspection of the raw series. The period is contrary to Warner (2022a), who gave a period of 9.9 h from much noisier data (RMS 0.04 mag).



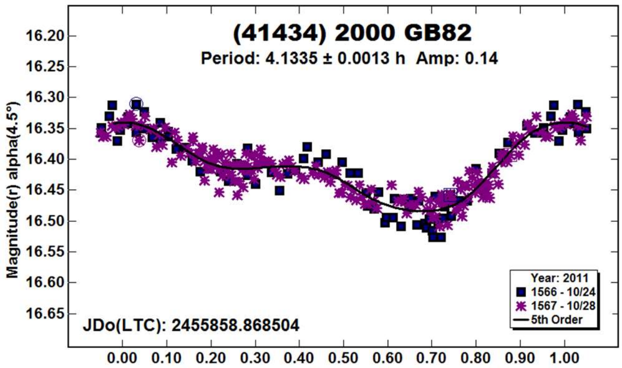
(34759) 2001 QL151. We obtained four nights of data using the Schmidt for this Mars-crosser as it moved at far-northern Declinations in 2011 Jan. Despite some slight peculiarities in the nightly series (likely instrumental in nature), the period seems to be well-determined. The RMS scatter on the fit is 0.021 mag after averaging the 20-second exposures in batches of three.



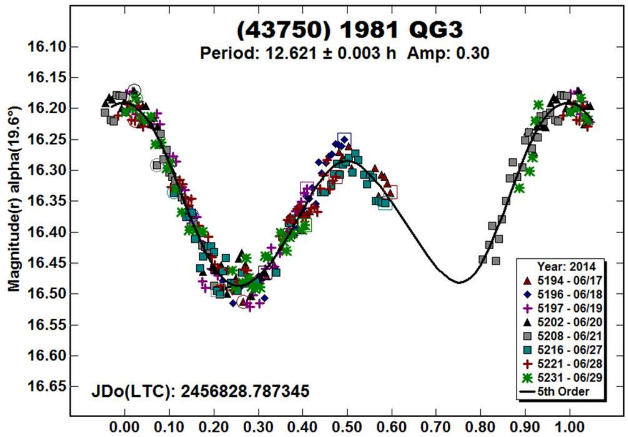
(36284) 2000 DM8. Linder et al. (2013) published the first lightcurve for this Apollo using data taken the week prior to ours. The Schmidt data cover two nights in 2011 Feb. The phased lightcurve shows the 30-second exposures binned into three-image 3-minute averages. The RMS scatter is 0.033 mag.



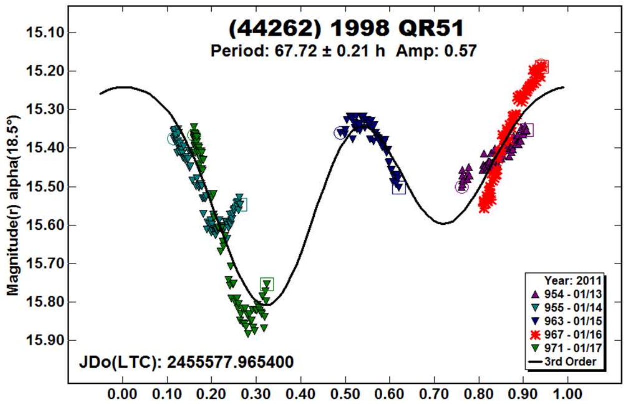
(41434) 2000 GB82. Two nights of 0.7-m photometry in 2011 Oct, with runs of over 7 hours each, revealed a smooth lightcurve of moderate amplitude for this Mars-crosser. The RMS scatter on the fit is 0.017 mag.



(43750) 1981 QG3. The orbit of this main-belt asteroid has moderate eccentricity, which brings it in to a perihelion distance of 1.85 AU. Relatively short summer-solstice runs in 2014 Jun show a period near 12½ hours, but the 12-day baseline did not allow the rotational phase coverage to shift enough to get a complete lightcurve. The period is nevertheless well-determined. The RMS scatter is 0.020 mag from 5-minute exposures using the 0.7-m telescope. Our period confirms the one by Ďurech et al. (2020) from sparse ATLAS photometry.

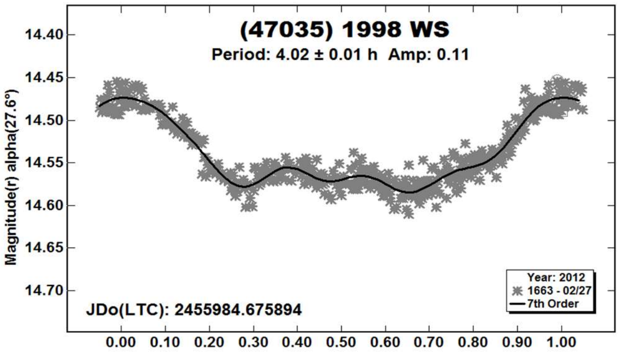


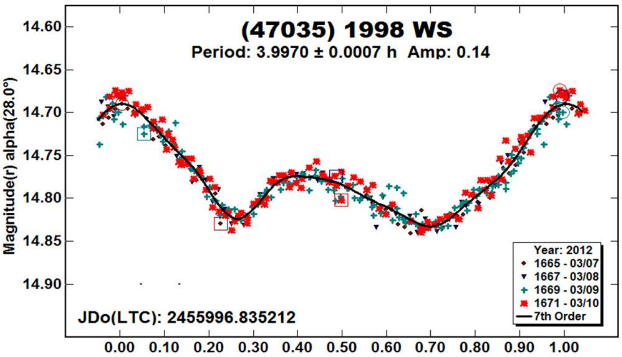
(44262) 1998 QR51. After taking data over five consecutive nights in 2011 Jan using the 0.7-m telescope, it became clear that this Phocaea was a long-period tumbler, so observing was abandoned.

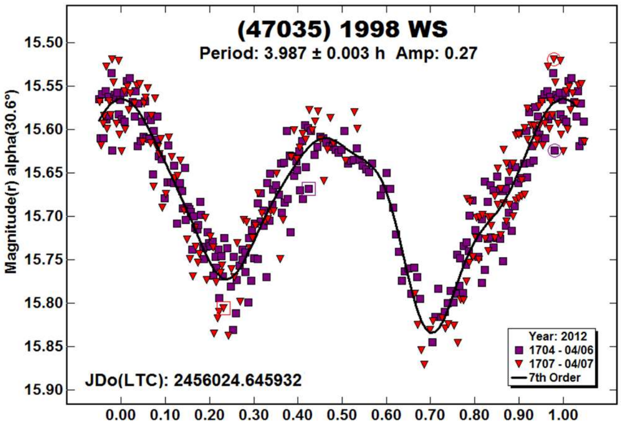


The lightcurve shows an approximate dominant period, but clearly the object requires much more extended observation. Pál et al (2020) show a period of about 77 h from TESS data. Although this is not present in our data, it is not significant, since the tumbling nature is not dealt with in either case.

(47035) 1998 WS. Warner et al. (2012a) previously published a pole-orientation and shape-model for this Mars-crosser based on data spanning a single apparition from near opposition to evening quadrature. Our data were part of this, comprising seven nights of 0.7-m data (60- and 90-second exposures) in 2012 Feb-Apr.



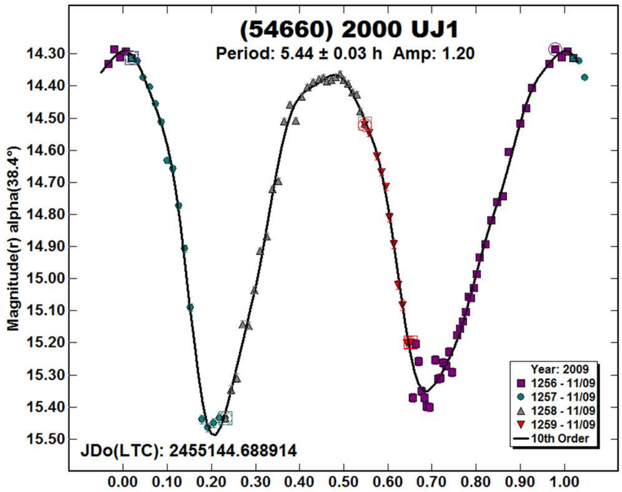




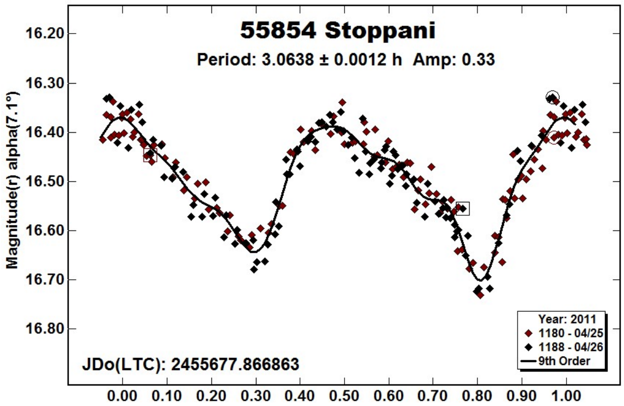
We have now adjusted the data more closely to Sloan r′, and show each group of nights separately, plotted at the same vertical scale. The first night covered nearly 10 hours, about 2½ rotational cycles, and the character is essentially monomodal with a broad minimum. Two weeks later the lightcurve was a typical bimodal one of moderate amplitude. Finally, in early April the amplitude had doubled – and all this with little change in phase angle. The RMS scatters on the plots are 0.010, 0.010 (with three-image, 5-minute averaging), and 0.028 mag.

(54660) 2000 UJ1. Student observer Emily Bevins followed this fast-moving (about 7° per day) Amor with the Schmidt for 5½ hours on 2009 Nov 9. The data (ninety 14-second exposures) were reduced with four sets of comparison stars. The rotation period turns out to be about the same length as the data-series, and ordinarily this would be suspicious. However, the large amplitude in this case removes the ambiguity, so the short run merely makes the period itself uncertain compared to having multiple nights.

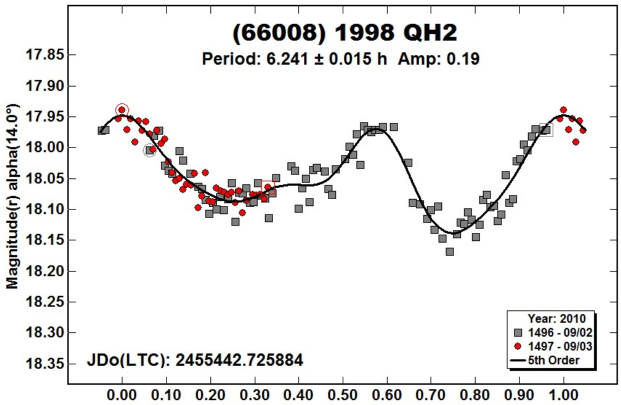
We adjusted the zero-points of each session by measuring one or two overlapping frames in each batch against the two sets of comp stars. The RMS scatter on the fit is 0.034 mag.



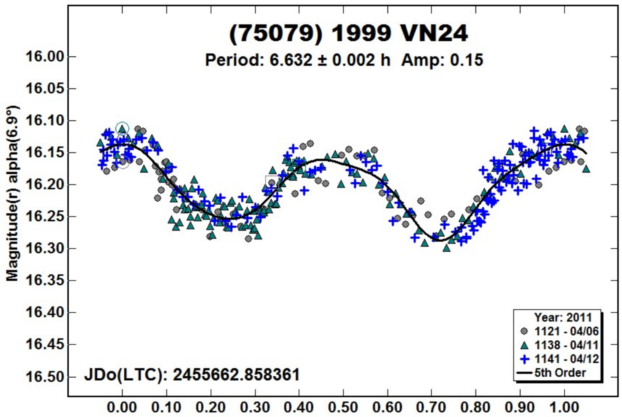
55854 Stoppani. Warner (2011) published the first lightcurve for this Hungaria from data taken shortly after ours. We obtained runs of more than 7½ hours (~2.5 rotational cycles) on consecutive nights in 2011 Apr using the 0.7-m telescope. The RMS scatter is 0.029 mag; the somewhat over-fit Fourier curve seems to be required to trace the sharp minima.



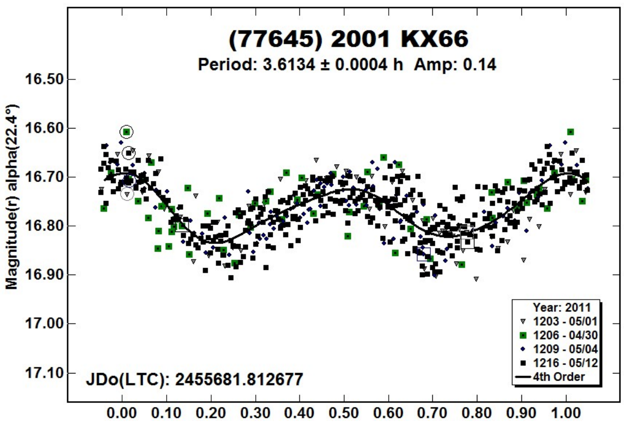
(66008) 1998 QH2. Warner (2016a) showed a lightcurve for this Apollo (a LONEOS discovery) of 7.09 h, assigned quality U = 2+. The periodogram of our two nights of 1.1-m telescope data in 2010 Sep does not show this period, but instead a somewhat shorter one. The RMS scatter on the plot is 0.020 mag.



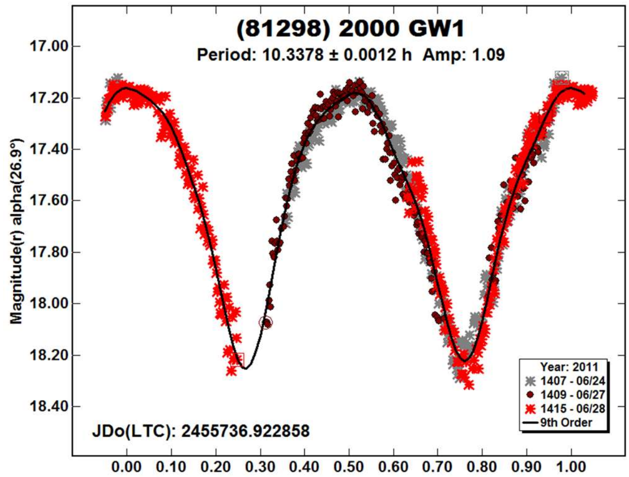
(75079) 1999 VN24. Three nights of 0.7-m data in 2011 Apr yielded a complete, well-defined lightcurve of moderate amplitude for this Mars-crosser. The 90-second exposures gave RMS scatter of 0.021 mag. We thus confirm the period by Waszczak et al. (2015) from sparse PTF data taken about the same time.

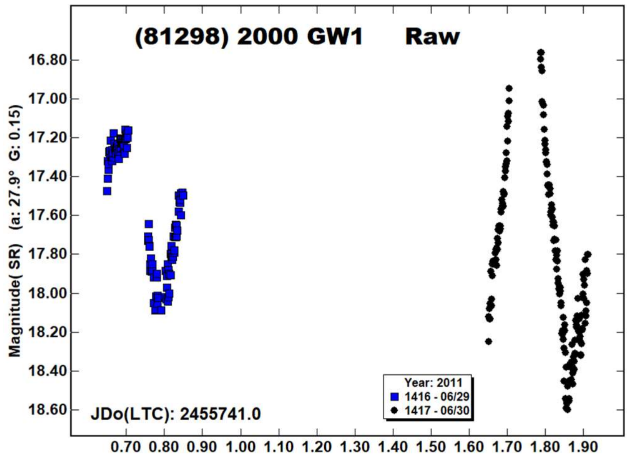


(77645) 2001 KX66. Using both the 0.7-m telescope (three nights, R_c filter) and Schmidt (final night, unfiltered), we obtained runs on this Phocaea of between 7½ and 8 hours duration in 2011 Apr-May, covering more than two rotational cycles each night. The period is thus well-determined despite the RMS scatter of 0.04 mag.

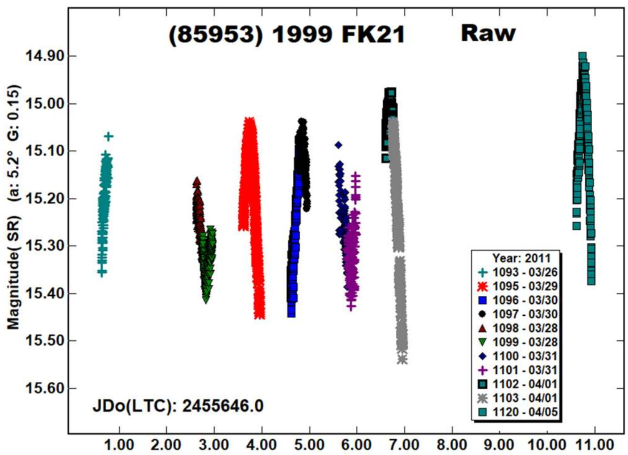


(81298) 2000 GW1. Three nights in 2011 Jun using 60-second exposures on the Schmidt gave a nearly complete large-amplitude lightcurve for this Phocaea. The RMS scatter on the fit is 0.05 mag due to the faintness at minimum. Two subsequent nights are more problematic; one was somewhat cloudy, and the other clear but the data showed a smooth but peculiar form. These are shown in the raw plot below. There is no previous lightcurve photometry published.

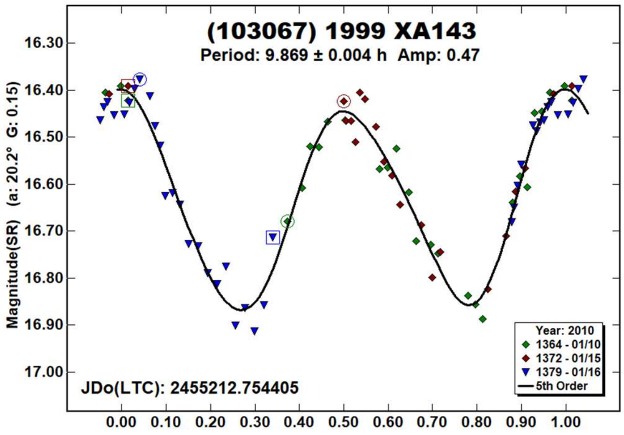




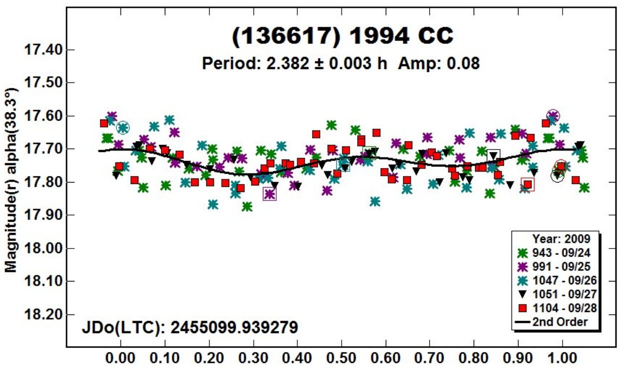
(85953) 1999 FK21. This 0.6-km Aten is a known tumbler (Pravec, 2019web), which we observed on seven nights in 2011 Mar-Apr using the Schmidt. Comprising nearly 2600 frames of 20- and 30-second exposures, this photometry will be analyzed together with further data by Pravec et al. in a separate publication, so for now we show a raw plot of our coverage.



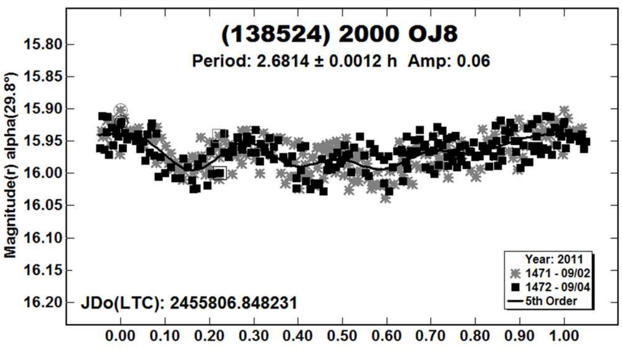
(103067) 1999 XA143. We obtained three nights of sparse data for this Apollo using the Schmidt in 2010 Jan. The lightcurve is only roughly outlined, but the period determination seems reliable due to the 6-day baseline, and is not far from previous work, starting with Galád et al. (2005). The RMS scatter on the fit is 0.04 mag.



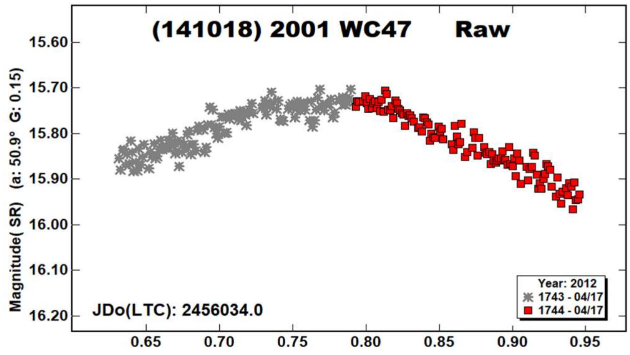
(136617) 1994 CC. This Apollo is now known to be a triple, having two small satellites identified in radar data (Brozović et al., 2011). We observed the object in 2009 Sep and Oct using the Schmidt, but it was really too faint for the telescope given the small amplitude. However, data from the first lunation fit a period close to the rotation period for the primary determined by Brozović et al (2.389 h). The RMS scatter is 0.05 mag.



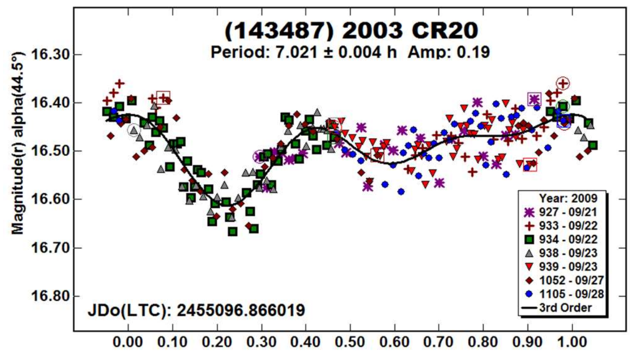
(138524) 2000 OJ8. Our data over two nights in 2011 Sep using the 0.7-m telescope had barely high-enough precision to see the small-amplitude short-period quadrimodal lightcurve in this Amor. Luckily there are data from Pravec (2011web) on the same nights confirming the period. The RMS on the phased plot is 0.020 mag.



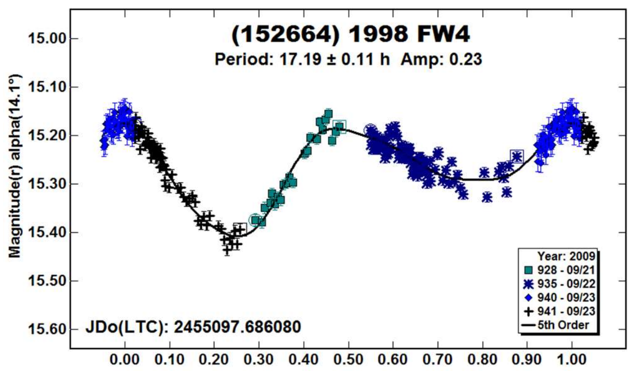
(141018) 2001 WC47. Over three lunations in 2012 Mar-May, we obtained lightcurve fragments using the 0.7-m telescope for what seems to be a long-period tumbling Amor. Based on data from the same apparition, Warner (2012b) suggested a period of 16.5 hours. However, any periodicity cannot be so short as that, since the example 7½-hour run shown below has only a broad maximum.



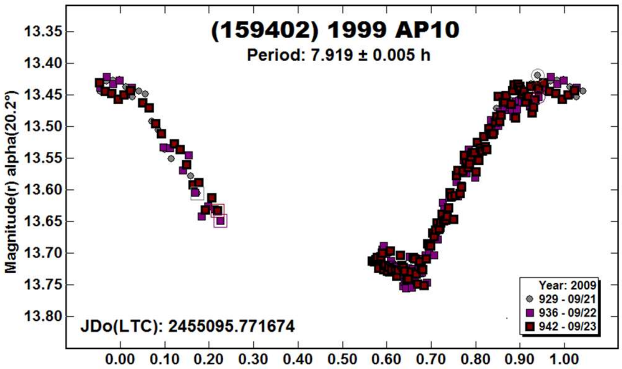
(143487) 2003 CR20. Schmidt data were obtained for this Apollo over a seven-night interval in 2009 Sep. The 90-second exposures yielded a somewhat noisy lightcurve with a period of about 7 h; the RMS scatter on the fit is 0.04 mag.

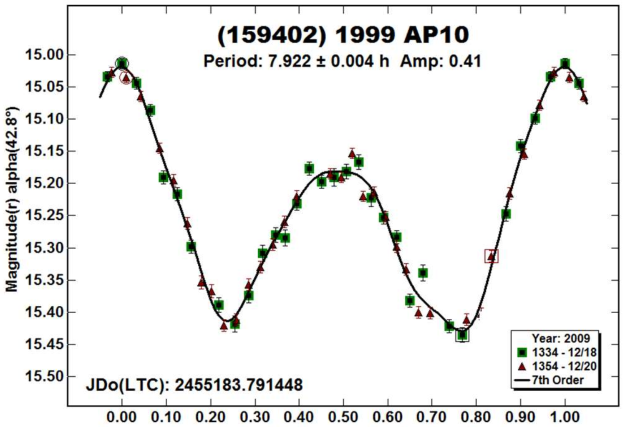


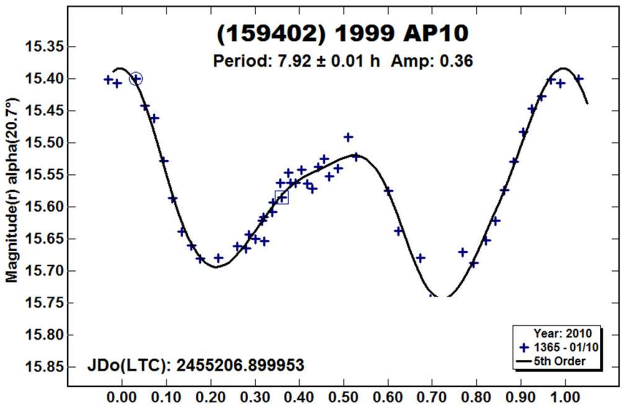
(152664) 1998 FW4. We obtained three nights of data in 2009 Sep for this Apollo using the Schmidt (20- to 30-second exposures), which gave barely enough rotational phase coverage for this somewhat slow rotator. The RMS scatter on the fit is 0.017 mag. The period we derive is similar to, but somewhat shorter than that of Warner (2014a), whose data cover a longer baseline. From a more recent run, Warner and Stephens (2022a) indicate things might be ambiguous.



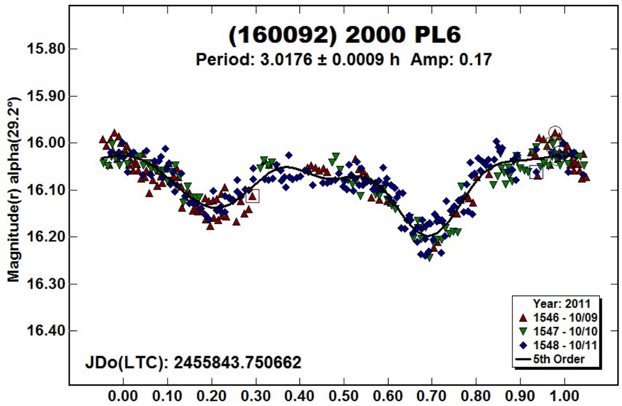
(159402) 1999 AP10. Our Schmidt data for this Amor span four months at the end of the 2009 into 2010. The first three nights were combined with other photometry acquired during the same range of dates and published by Franco et al. (2010). This group and Hasegawa et al. (2018) both obtained periods near 7.91 hours. Reanalysis of our complete series, after adjustment of the comparisons stars and including additional nights, show periods about 0.01 h longer – perhaps not a significant difference, but other later observers also get 7.92 h. The three lightcurves here are from 2009 Sep and Dec, and a final single-night run in 2010 Jan. The RMS scatter on all three plots, shown at the same vertical scale, is between 0.015 and 0.020 mag.



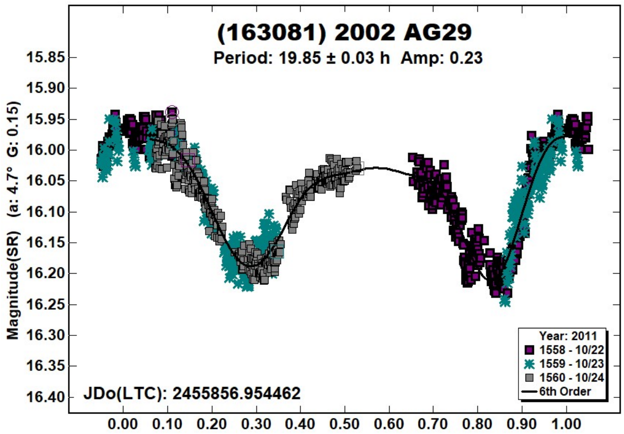




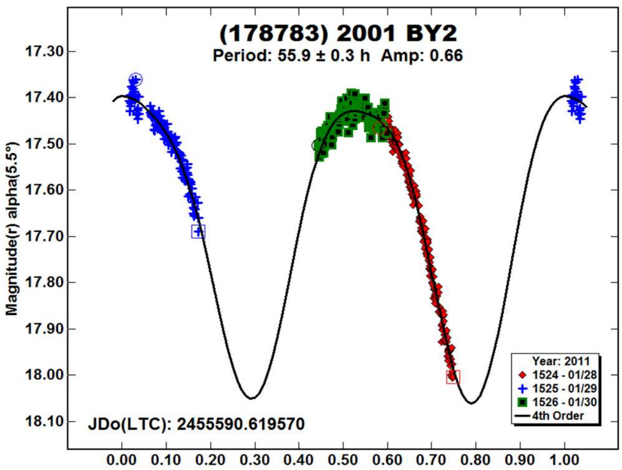
(160092) 2000 PL6. Three nights in 2011 Oct using the 0.7-m telescope showed a fairly short period lightcurve of modest amplitude for this Amor. The RMS scatter on the fit is 0.024 mag. We obtained two additional nights using the Schmidt, but they are much less good.



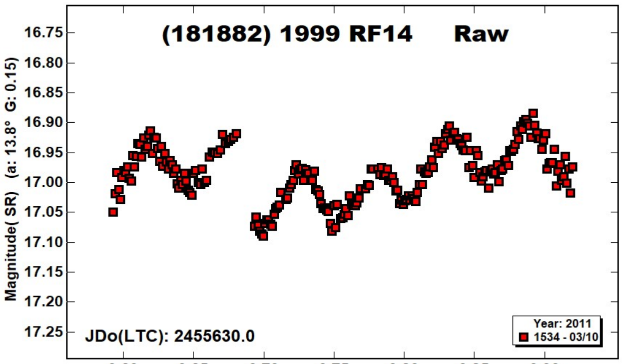
(163081) 2002 AG29. Pravec (2019web) has given the first rotation period (19.64 h) for this Apollo. Our Schmidt data from 2011 Oct are somewhat ragged and do not cover the secondary maximum, which could explain the slightly different period-determination. The RMS scatter is 0.019 mag with three-image 4-minute averaging.



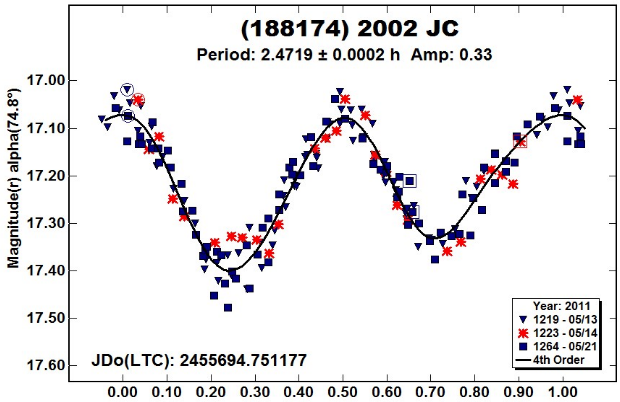
(178783) 2001 BY2. Despite getting three full-night runs in 2011 Jan of between 8.5- and 9-hours duration using the 1.1-m telescope, we caught only one extremum properly on this Mars-crosser. The nightly trends, however, constrain the period fairly well. The RMS scatter on the rough fit is 0.016 mag. A more realistic uncertainty on the period is perhaps 1 to 2 hours, compared to the smaller formal error shown in the lightcurve legend.



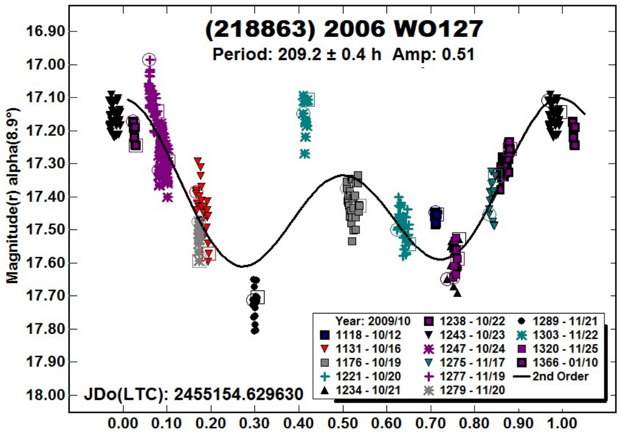
(181882) 1999 RF14. Our photometry from 2011 Mar for this Mars-crosser is problematic. There is a short-term wobble of about 0.1-mag amplitude, but also a longer-term slow variation. This could be a very wide binary, and the small, short variation is from the rotation of a companion, but otherwise the data are inscrutable. We have four nights of Schmidt data and three more 8-hour runs using the 1.1-m telescope. An example of the (better) 1.1-m data is shown.



(188174) 2002 JC. This Aten was passing near the north ecliptic pole in 2011 May when we got three nights of photometry using the Schmidt. The fairly short period is unambiguous, with RMS scatter of 0.033 mag after averaging the data in three-image 4-minute bins. Our period determination is very similar to previous results, starting with Polishook and Brosch (2008). The alternative 2.74-h period suggested by Warner (2014b) is not present in our data.

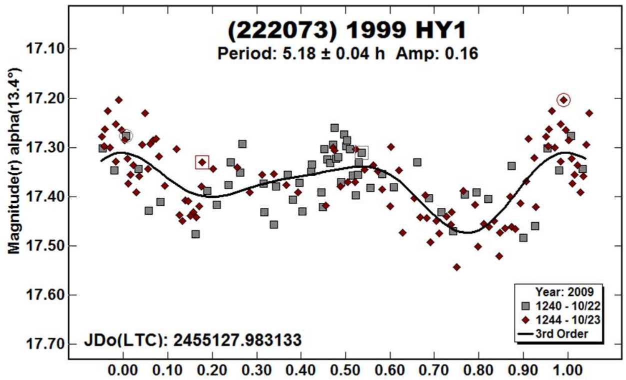


(218863) 2006 WO127. The LCDB cites a short, high-precision rotation period and spin-axis for this Apollo (Ďurech et al., 2018).

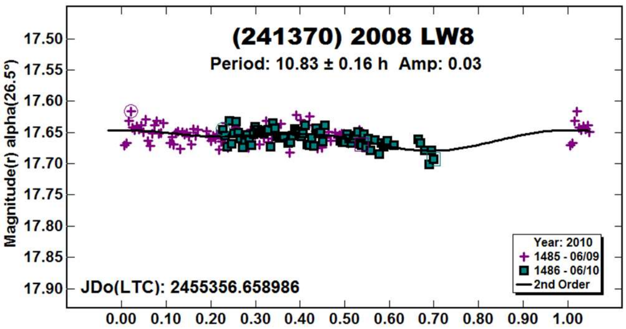


In our many nights of Schmidt data from 2009 Oct to 2010 Jan there is no such short cycle present unless the amplitude is quite small. Instead, we see evidence for a long-period tumbler. The data show a persistent cycle-length of roughly 210 hours, but surely other components are involved.

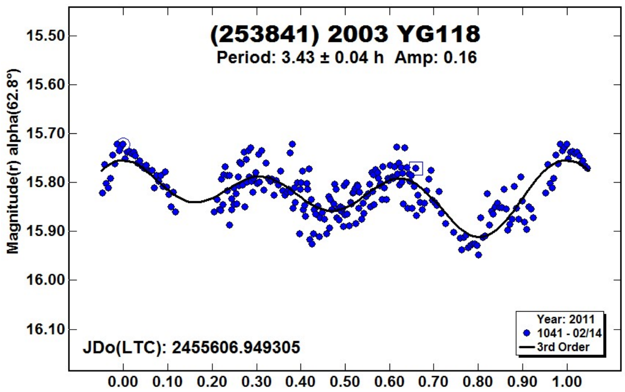
(222073) 1999 HY1. Previously Warner (2017) found a period for this Amor of 10.37 h with some uncertainty. Two nights of Schmidt data in 2009 Oct, totaling 16 h on target, with similarly-poor internal precision near the faint working limit of the telescope, suggests instead half this period with similar lightcurve morphology. The RMS scatter on the fit is 0.05 mag.



(241370) 2008 LW8. The two short 2010 Jun nights we obtained on this Apollo were insufficient to cover the rotation period. Indeed, the simple fit shown here is possibly half the true period of the very-small-amplitude lightcurve. The 3-minute exposures using the 1.1-m telescope have an RMS scatter of 0.012 mag.

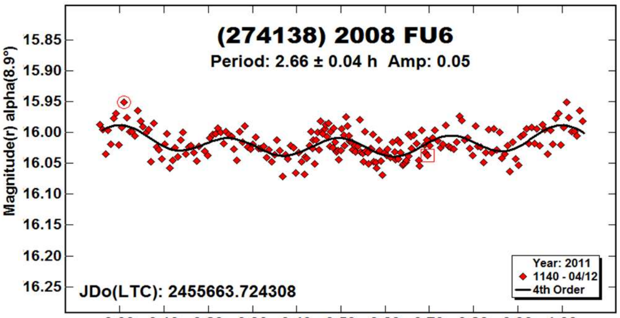


(253841) 2003 YG118. We got only a 5-hour Schmidt run on one night in 2011 Feb for this Apollo.

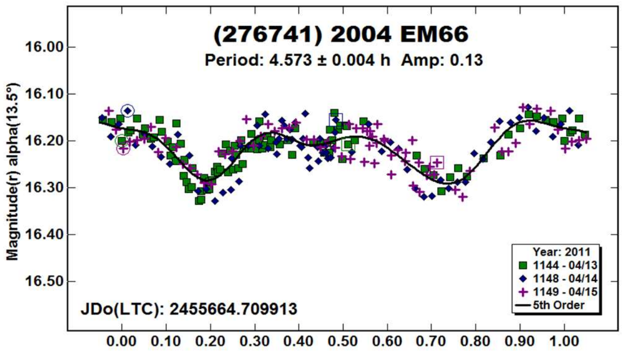


Previously (Skiff, 2011web), we used the same data to fit a double-mode period of 2.27 h, rated U = 2- in the LCDB. This is unlikely given the relatively large size of the object. We give here a tri-modal version that is probably not better (still quality 2-), but brings the period into a more likely range. The RMS scatter is 0.033 mag.

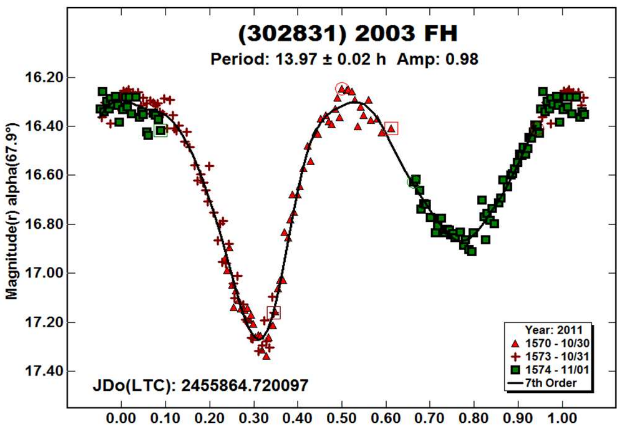
(274138) 2008 FU6. Warner (2014b) showed data for this Apollo from 2014 suggesting a short period of about 2.85 h along with a possible secondary period of 12.7 h. We cannot reproduce this in our single-night 3-hour run with the Schmidt in 2011 Apr. A quadrimodal period of 2.66 h with small amplitude is shown here, which could be spurious. The RMS scatter on the fit is 0.018 mag.



(276741) 2004 EM66. Observation of this Mars-crosser in 2011 Apr was hampered by clouds on three nights using the 0.7-m telescope. After adjusting the comparison stars to Sloan r´, we find an undistinguished moderate-amplitude lightcurve. The RMS scatter on the fit is 0.027 mag.

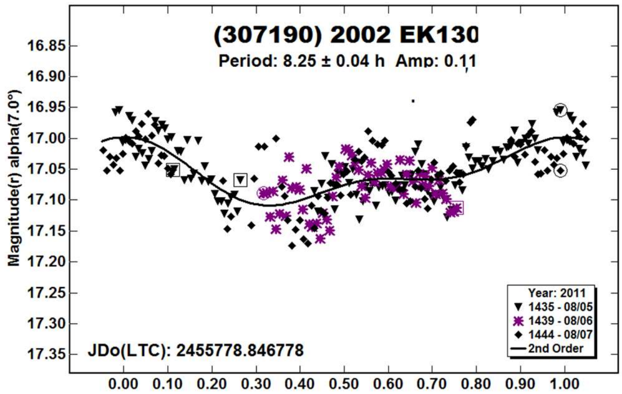


(302831) 2003 FH. This Apollo was followed using the Schmidt on three consecutive nights in 2011 Oct, though the runs were not especially long.

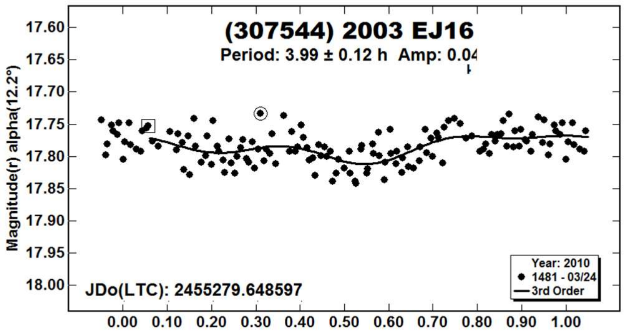


The data fit a period close to 14 hours with fairly large amplitude. The lightcurve has the 45-second exposures binned as three-image 4-minute averages; the RMS is 0.05 mag.

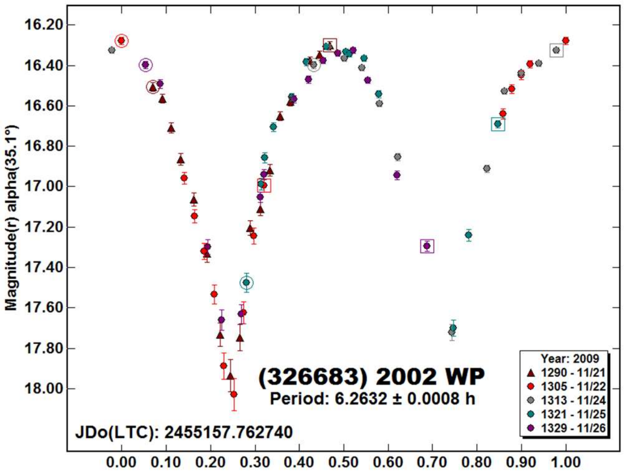
(307190) 2002 EK130. This Mars-crosser was discovered with the LONEOS Schmidt. Using that telescope we obtained three nights of data in 2011 Aug. Though quite noisy, an 8.25 h period seems possible with low confidence. The RMS scatter is 0.033 mag after binning the data into three-image 4-minute averages.



(307544) 2003 EJ16. We followed this Mars-crosser, another LONEOS discovery, on only one night with the 1.1-m telescope in 2010 Mar. The 7-hour run of 3-minute exposures allows only a tentative and uncertain period determination due to the very small amplitude. The RMS scatter on the fit is 0.022 mag.

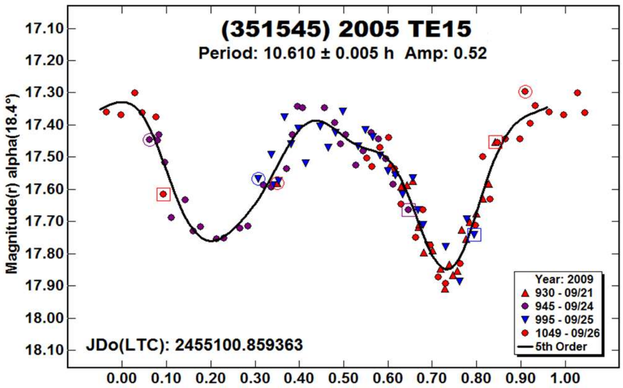


(326683) 2002 WP. The earliest published lightcurves for this 0.5-km Amor date from the 2016 apparition (e.g., Behrend, 2016web).

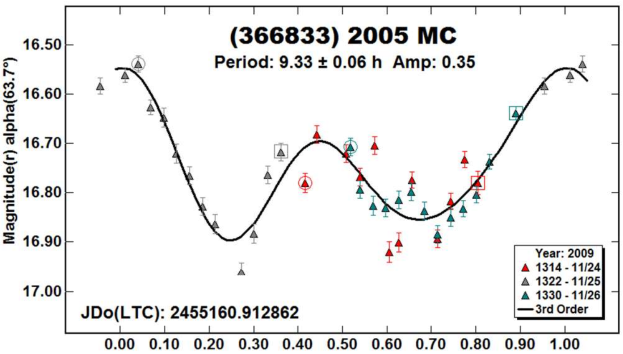


Seven years prior, we obtained data over two lunations using the Schmidt. Coverage in 2009 Nov allowed the period to be determined accurately; our 2009 Dec data are incomplete. The amplitude is 1.65 ± 0.03 mag, larger than previously observed, and the RMS scatter is 0.05 mag.

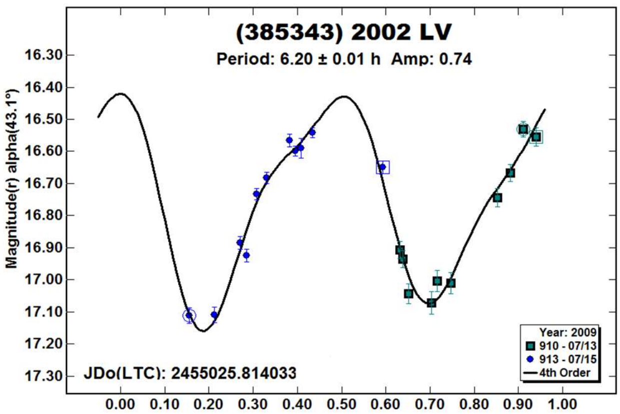
(351545) 2005 TE15. This Apollo has no previous photometric results in the LCDB. Although it was near the faint limit of the Schmidt, we observed it on four nights at the time of its 2009 Sep close approach. The lightcurve is rather noisy (RMS scatter 0.05 mag), but shows that it is a moderately-slow rotator.



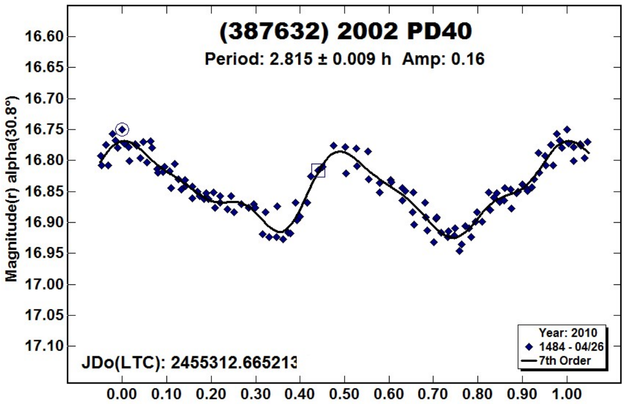
(366833) 2005 MC. Three nights of sparse data in 2009 Nov using the Schmidt with 3-minute exposures give only a tentative rotation period for this Amor. The RMS scatter is 0.05 mag.

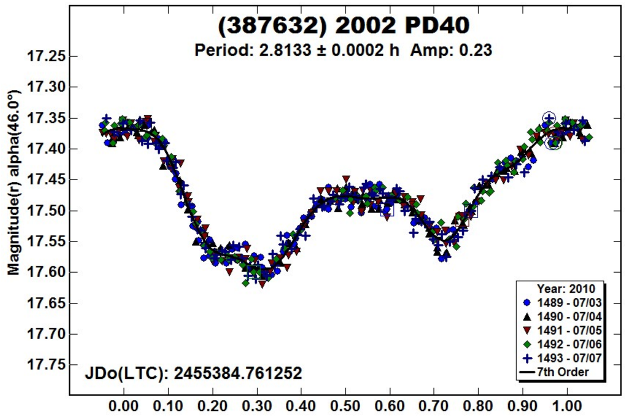


(385343) 2002 LV. We got only sparse data on two nights in 2009 Jul for this Apollo using the Schmidt. We force-fit the data to the period first found by Pravec (2002web). The RMS scatter on this rough fit is 0.05 mag.

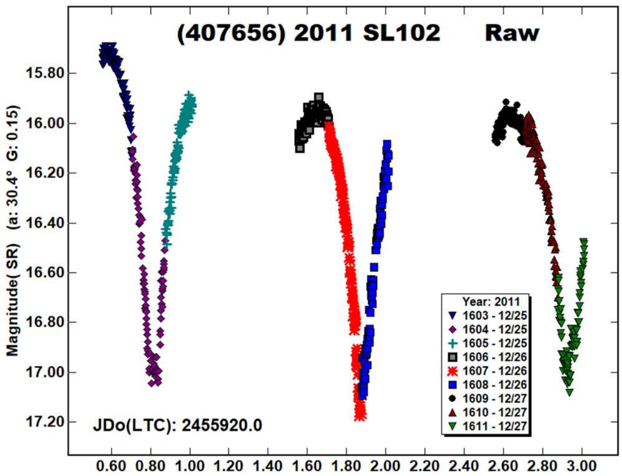


(387632) 2002 PD40. We obtained lightcurves at two stages during the 2010 apparition using the 1.1-m telescope: a single 8-hour run in April, then five consecutive nights in early July. The latter series defines the lightcurve and period of this Mars-crosser to a high degree. The lower phase-angle April lightcurve is obviously different in morphology and of smaller amplitude. The RMS scatter on the two lightcurves, which are plotted at the same vertical scale, is 0.015 and 0.013 mag, respectively.



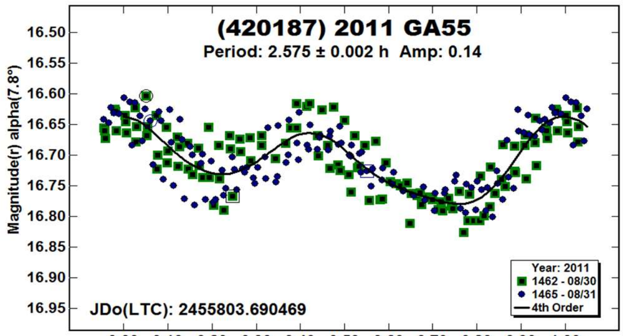


(407656) 2011 SL102. Three good nights in 2011 Dec using the 0.7-m telescope on this Amor yielded what look like parts of a large-amplitude lightcurve with period slightly longer than a day.

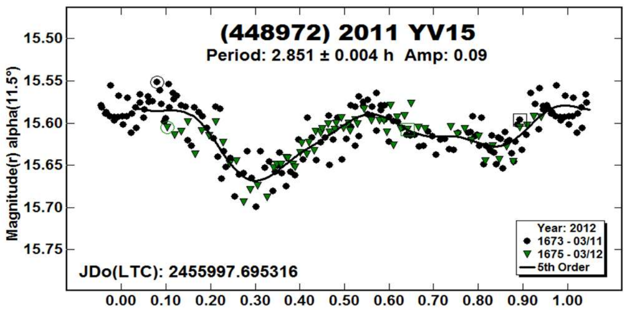


Each nightly run is nearly 11 hours long. The data, however, do not phase well with any period. We are confident that the photometric zero-points are consistent to within a few percent for the series, precluding a problem with the maximum on the first night being ~0.2 mag brighter than the following two. Neither do the shapes and slopes of the second and third nights match when those nights are aligned on their maxima. Perhaps some tumbling is involved, but we simply do not have enough coverage to say much more.

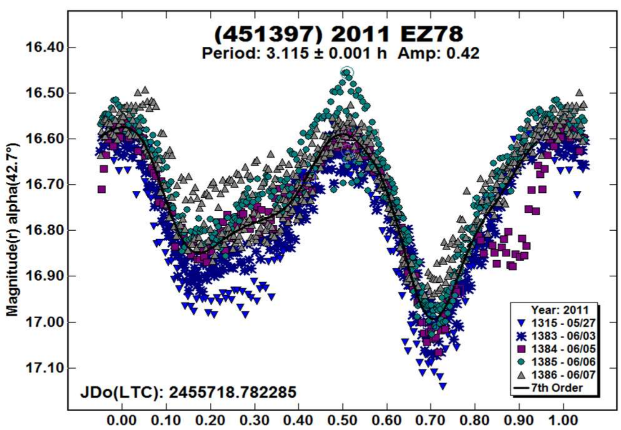
(420187) 2011 GA55. Two 7-hour runs using the Schmidt on this Amor in 2011 Aug showed a short-period lightcurve of modest amplitude. The phased plot has the 679 measurements from 45-second exposures binned into 230 three-image 4-minute averages; the resulting RMS is 0.031 mag.

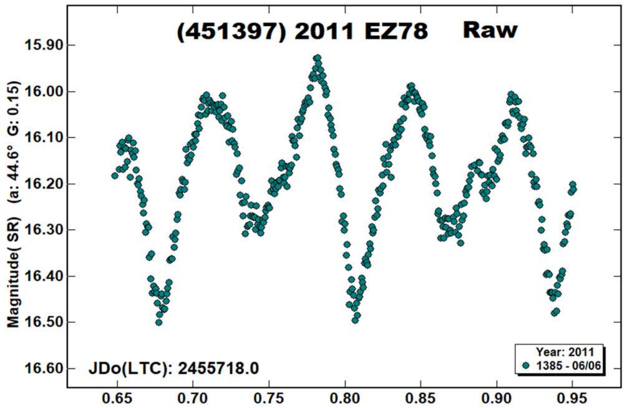


(448972) 2011 VY15. We observed this Amor on two consecutive nights with the 0.7- and 1.1-m telescopes in 2012 Mar, getting about 9 hours total on the target and more than a full cycle each night. The period is short and has small amplitude. The RMS scatter on the fit is 0.017 mag.



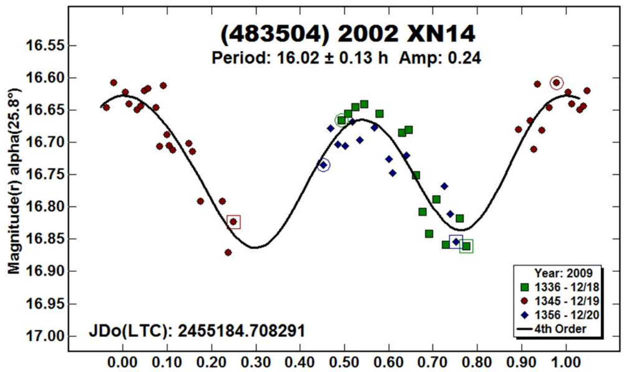
(451397) 2011 EZ78. Our series using the Schmidt in 2011 May-Jun on this Amor showed that it was a probable binary or tumbler with lightcurves that did not repeat from night-to-night.



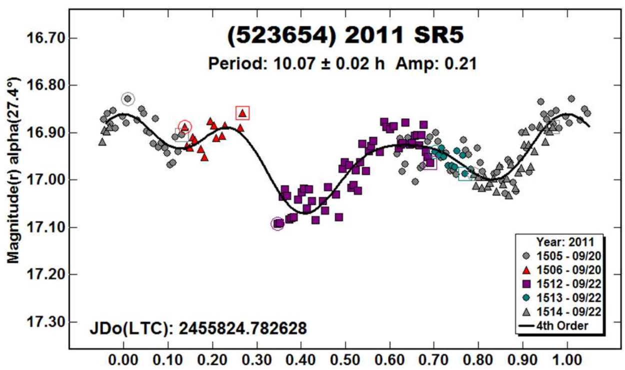


The dominant period is shown in the first plot, which phases all the data, and in which what look like mutual events can be seen. The second plot is a single full night run, showing that the lightcurve does not repeat even on a short timescale (the RMS scatter in this plot is about 0.02 mag). Pravec (2011web) suggests a possible second period of about 55 h along with unconfirmed attenuation events.

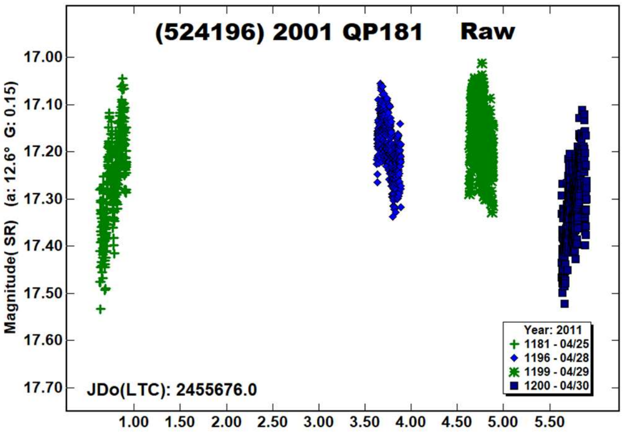
(483504) 2002 XN14. Sparse data for this Apollo on three nights using the Schmidt in 2009 Dec allow only an approximate and uncertain determination of the rotation period. The lightcurve here is the only bimodal solution in the periodogram. The RMS scatter on the fit is 0.032 mag. There is no other published photometry.



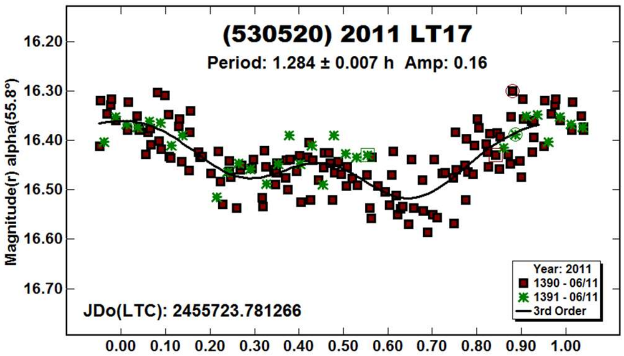
(523654) 2011 SR5. Our two nights of Schmidt data in 2011 Sep, starting the night after this Apollo was discovered, were relatively noisy and lack temporal coverage to get a reliable rotation period. We show a *tentative* solution, which could well be wrong. The RMS scatter, with the points averaged into three-image 4-minute bins, is 0.029 mag.



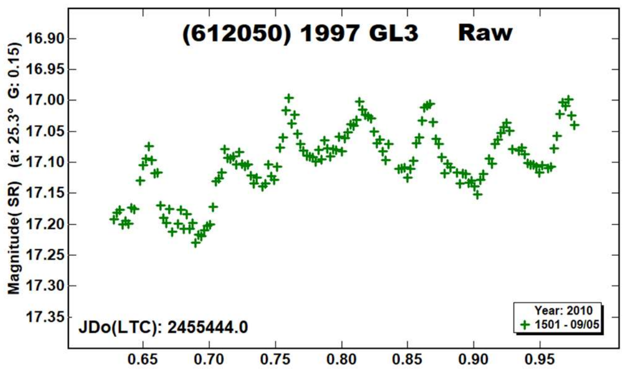
(524196) 2001 QP181. After four nights of Schmidt observing in 2011Apr we found no periodicity expressed in the data, so abandoned observing it. A period we gave previously (Skiff, 2011web) is spurious. The Amor is a likely tumbler with a complex lightcurve. The raw data-plot shows the series we obtained; at this magnitude level the typical RMS scatter is 0.04 mag.

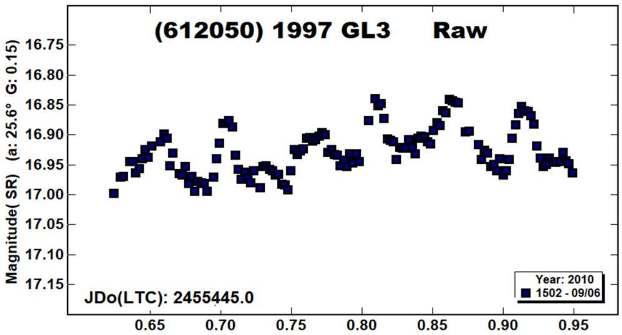


(530520) 2011 LT17. We followed this 150-meter Apollo for 6½ hours on 2011 Jun 11 (essentially dusk-to-dawn) using 30-second exposures on the Schmidt. The period is fairly short, but not unusually so for a small object. The RMS scatter on the fit is 0.04 mag after averaging the images by pairs.



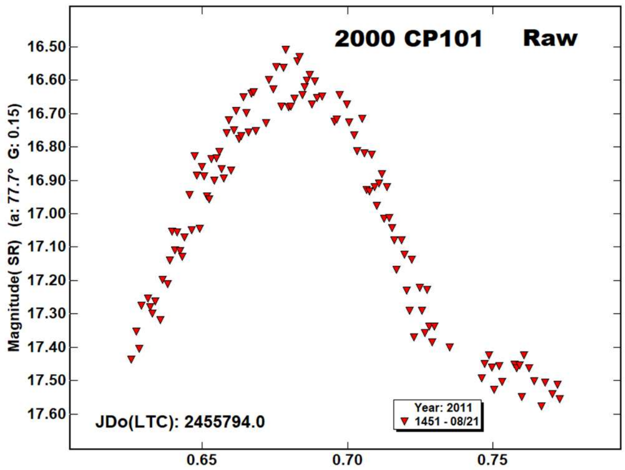
(612050) 1997 GL3. Pravec et al. (1998) first remarked upon the "several bumps and wiggles" in the complex lightcurve for this Apollo. They concluded that the period was 7.57 h, but consider that either the shape may not be symmetrical with respect to a 180° rotation, or that the body is in an excited rotational state.



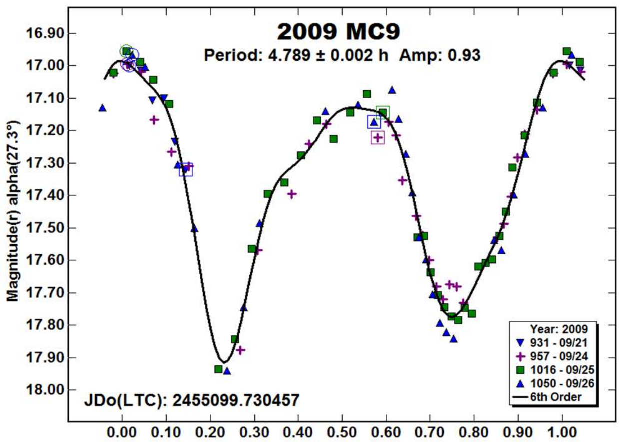


Our two nights of 1.1-m telescope data in 2010 Sep, each about 8 hours long, do not fit the 7.57-h period very well, and each night's series is subtly different. The phase-angle was also significantly higher (Pravec about 8° versus our 25°). We thus show the two raw plots. As can be seen from the point-by-point consistency, the internal precision is quite good (~0.015 mag RMS).

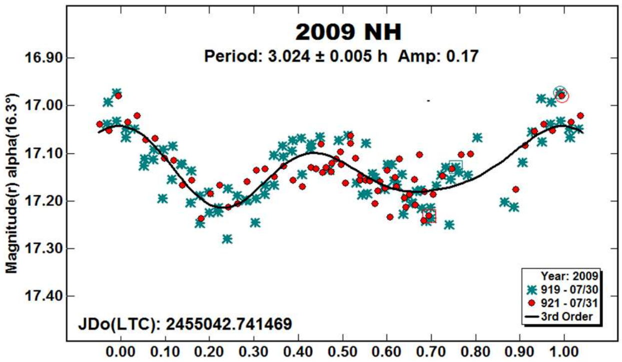
2000 CP101. Our single-night 3½-hour run in 2011 Aug showed only one pair of extrema for this Apollo. This suggests a period in the range of 10-12 hours, but we can say no more from these 45-second exposures with the Schmidt.



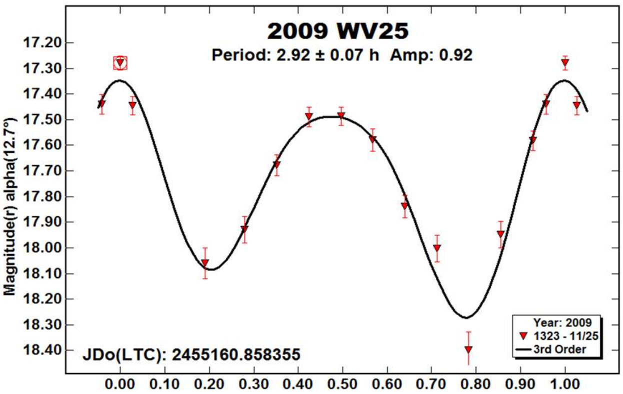
2009 MC9. This Amor was another object near the faint limit of the Schmidt. Our four nights of data in 2009 Sep (90-second exposures) produced a lightcurve similar to that of Behrend (2009web) from data by Silvano Casulli. The RMS scatter on the fit is 0.05 mag.



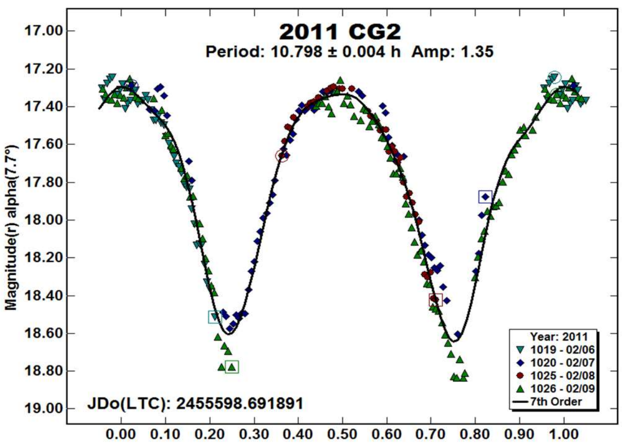
2009 NH. Albino Carbognani (2011) observed this Amor in 2009 Aug, a few weeks after our first observations. The asteroid was fairly faint, and so data from our two nights with the Schmidt are somewhat noisy, with RMS scatter of 0.04 mag. We nevertheless obtained a period similar to Carbognani's.



2009 WV25. This small Apollo was observed three days after discovery in 2009 Nov for only 3 hours using the Schmidt. The period derived is also 3 hours, which we consider to be suspect. The RMS error on the fit is 0.08 mag. The LCDB shows that Bill Ryan (unpublished) observed it on the same night from Magdalena Ridge Observatory, assigning an approximate period of 5 hours, possibly tumbling, and amplitude 1.24 mag, compared to 1.1 mag here. The object was last observed for astrometry in 2014, and will not be coming around again for many years.

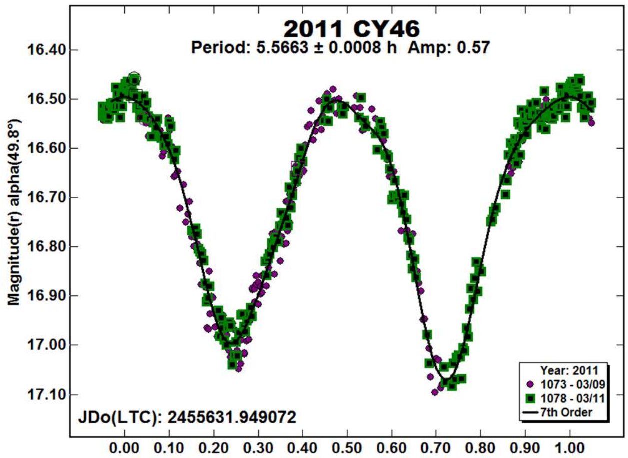


2011 CG2. Even at maximum this Apollo was at the faint working limit of the Schmidt using 45- and 60-second exposures.

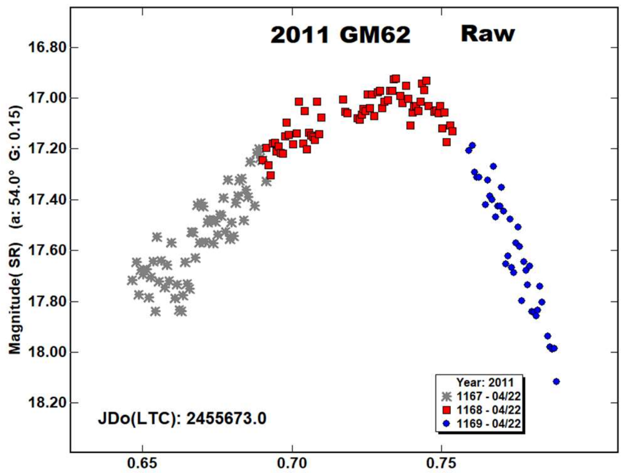


We show the lightcurve from 2011 Feb, shortly after discovery, and apparently the only such. The data below mag 18.5 are very poor, but the period seems to be secure thanks to the large amplitude. The RMS scatter on the fit is 0.08 mag after averaging the data in three-image 5-minute bins.

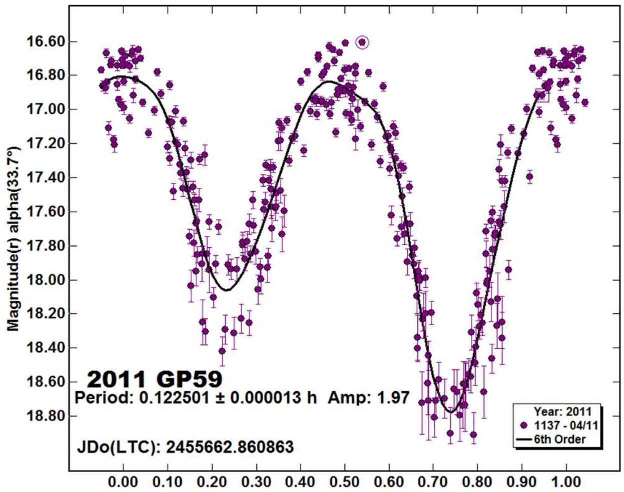
2011 CY46. We obtained two nights of data for this Apollo in 2011 Mar, about a month after discovery. The 45-second exposures using the Schmidt yielded a well-defined lightcurve of fairly large amplitude. The RMS scatter on the fit is 0.026 mag.



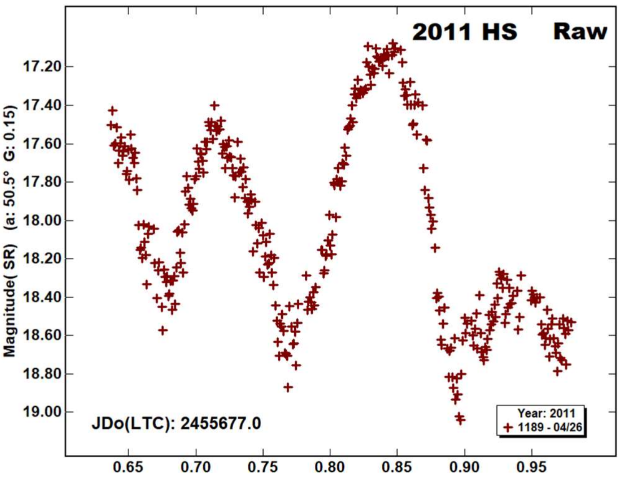
2011 GM62. We caught this small, fast-moving Apollo using the Schmidt for about 3½ hours on 2011 Apr 22 using 30-second exposures. The data span one maximum, so we infer only that the period could be in the range of 8 hours or so. At the high phase-angle involved, the amplitude is large.

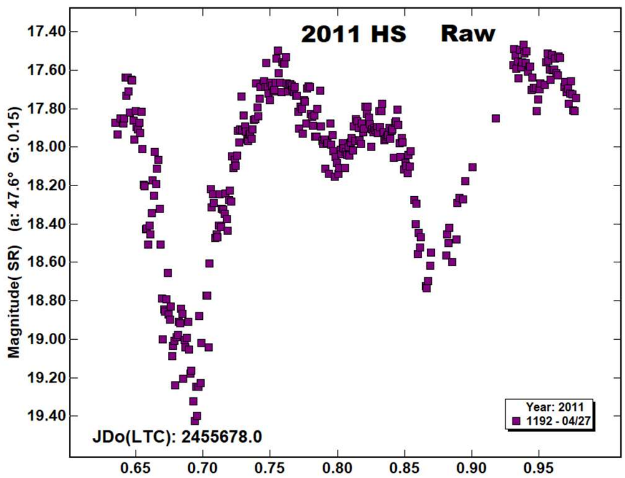


2011 GP59. This small (30 to 40 meters) Aten was observed for 6 hours on 2011 Apr 11 using the Schmidt. The period is very short, about 7.3 minutes, and the amplitude very large. Because the asteroid faded to near the telescope detection limit during the minima, the 45-second exposures gave very noisy data, saved only by the large amplitude. The lightcurve is displayed (warts and all) with error bars on the individual points to show how rapidly the errors increase as a function of magnitude. The RMS scatter on the fit is 0.21 mag(!). It is worth noting that the exposures were one-tenth the period, which reduces the apparent amplitude of the lightcurve (cf. Pravec et al., 2000).

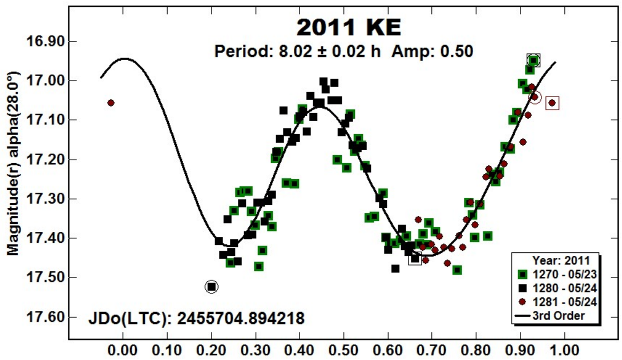


2011 HS. This 200-meter Apollo was another faint object observed using the Schmidt on the two nights following discovery in 2011 Apr. It turned out to be a tumbler, so the lightcurves do not repeat in any regular way night-to-night. The large phase-angle made the amplitudes very large, with rapid brightness changes on a short timescale. The two raw plots are shown to indicate the variation. The asteroid has not been observed since 2011 Jun.

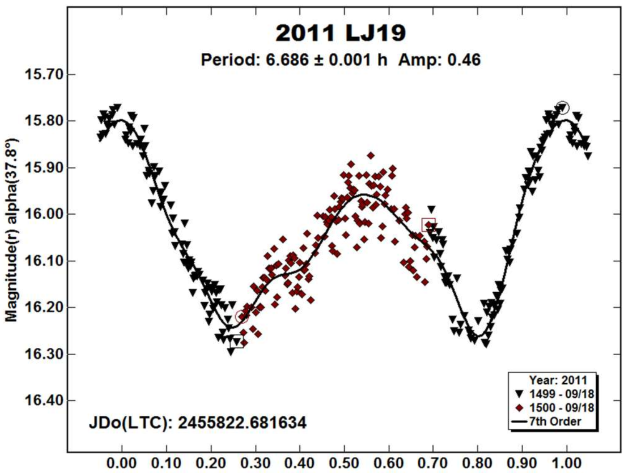


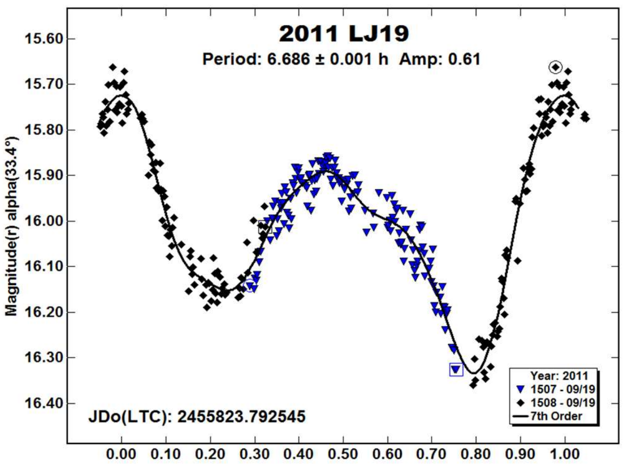


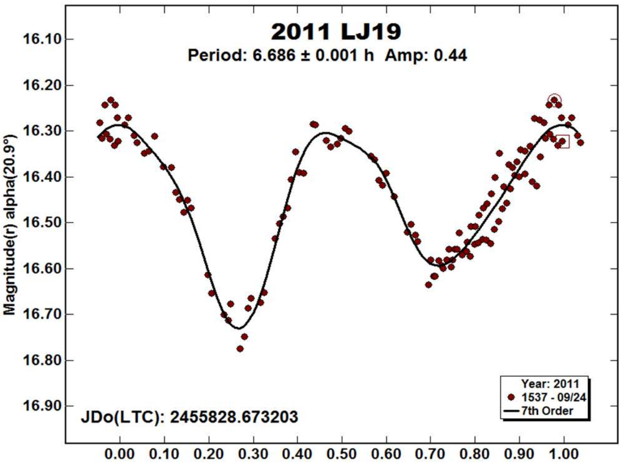
2011 KE. We obtained only rather poor and incomplete data for this Apollo using the Schmidt right after discovery in 2011 May. The period must be near 8 h, but with significant uncertainty. After binning the data into three-image 4-minutes averages, the RMS scatter is 0.06 mag.



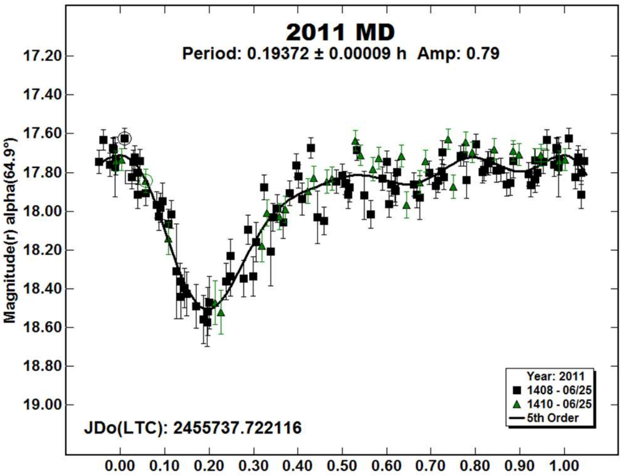
2011 LJ19. This fairly small Apollo has not been observed since 2011 Nov. We followed it on three nights in 2011 Sep using the Schmidt. The lightcurve morphology changed significantly each night, so we show three phased plots at the same vertical scale. The period has been fixed to that determined from the combined dataset, which has a realistic uncertainty of perhaps 0.01 h. On the first two nights the data are 30-second exposures and have RMS scatter of 0.04 and 0.035 mag. The final night, when the asteroid was fading, we averaged the 45-second exposures in three-image 4-minute bins; the RMS here is 0.034 mag.

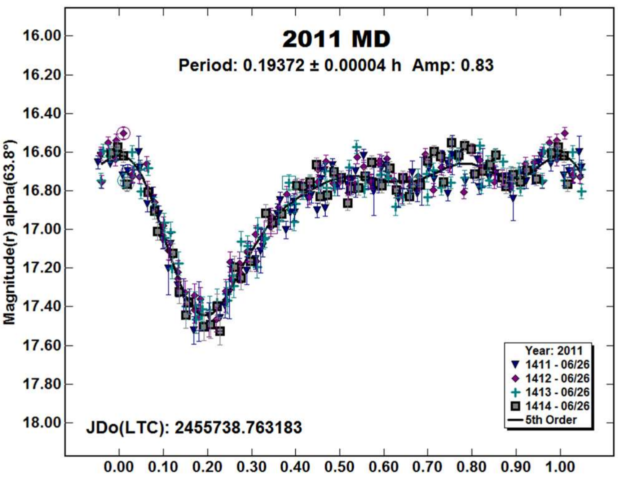




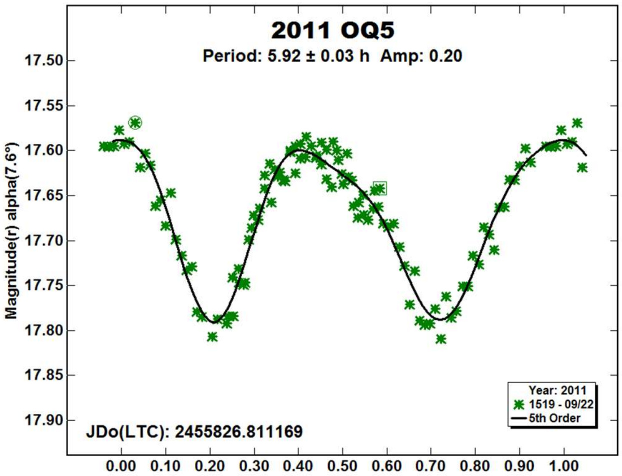


2011 MD. Several groups caught this very small (~6-meter) Apollo (Mommert et al., 2014) on the same nights in 2011 Jun. Our Schmidt data yield an unambiguous period of about 11½ minutes on two nights. The double period (cf. Vaduvescu et al., 2017) is excluded by a split-halves plot. The lightcurve morphology changed only slightly on the two nights, though on the second night it was brightening rapidly during the run. The RMS scatter on the phased plots, which are at the same vertical scale, is 0.09 and 0.06 mag, respectively.

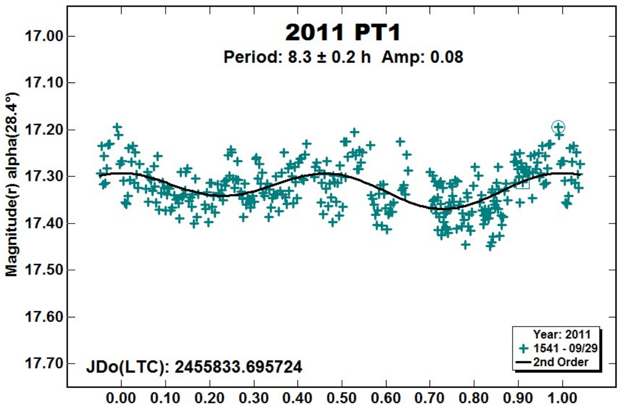




2011 OQ5. Our single 8-hour run in 2011 Sep with the 1.1-m telescope on this Amor revealed a regular bimodal lightcurve with some overlap in rotational phase coverage. The RMS scatter on the fit is 0.017 mag.



2011 PT1. We obtained a single-night 10-hour run on this Amor using the Schmidt in 2011 Sep. This shows a possible 8.3-hour period barely above the noise, which we consider tentative. If real, a single-mode 4-hour period is not excluded. The RMS scatter is 0.04 mag, so this is only a 2-sigma detection.



Incidental photometry

The following table shows objects for which we obtained only a few data-points, noisy data, or only a fraction of a rotational lightcurve for long-period objects. These resulted from interruptions by weather, the asteroid simply being too faint (often much fainter than predicted), or bad planning. The data are all adjusted to Sloan r´ as with the objects above.

455 Bruchsalia	5066 Garradd
5518 Mariobotta	(5646) 1990 TR2
6461 Adam	6485 Wendeesther
8648 Salix	(10145) 1994 CK1
11152 Oomine	(17274) 2000 LC16
24761 Ahau	(25362) 1999 TH24
(37336) 2001 RM	38628 Huya
49699 Hidetakasato	79360 Sila-Nunam
(86067) 1999 RM28	(105106) 2000 LS14
(123920) 2001 DW99	136108 Haumea
(138937) 2001 BK16	(143947) 2003 YQ117
(152563) 1992 BF	(162181) 1999 LF6
(162483) 2000 PJ5	(214088) 2004 JN13
(215442) 2002 MQ3	(217796) 2000 TO64
(217807) 2000 XK44	(263976) 2009 KD5
(363067) 2000 CO101	(366774) 2004 TB18
(416680) 2004 XD50	(429094) 2009 SG2
(490581) 2009 WZ104	2006 UR
2009 RN	2009 SH2
2011 CH71	

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Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
599	Luisa	2011 05/14	14.7	24	-1	9.57	0.01	0.18	0.01	MBO
1151	Ithaka	2011 09/08	12.6	333	10	4.93	0.01	0.15	0.01	MBO
1355	Magoeba	2011 07/16	23.3	304	33					HUN
1374	Isora	2011 03/01-03/05	5.4	150	-3	42.7	0.7	0.08	0.03	MC
1501	Baade	2011 10/14-10/15	17.2	354	-3	15.28	0.04	0.30	0.01	MBO
2060	Chiron	2017 09/02-09/13	0.7	357	4	5.92	0.02	0.02	0.01	CEN
2714	Matti	2012 05/05-05/15	16.8	205	9	9.2741	0.0007	0.24	0.01	MBO
3512	Eriepa	2011 01/15-01/17	10.1	131	2	6.785	0.006	0.26	0.02	MBO
3988	Huma	2011 07/01-07/23	67	306	41	10.53	0.01	0.26	0.03	NEO
4015	Wilson-Harrington	2010 01/10	40.3	60	1	3.61	0.15	0.13	0.02	NEO
4103	Chahine	2018 02/01-03/20	13.3,18.1	135	30	105.	2.	0.60	0.05	PHO
4132	Bartok	2011 04/22-04/28	9.3	224	22	3.2971	0.0003	0.34	0.02	PHO
4287	Trisov	2011 03/11-03/24	8.2	162	7	5.4936	0.0004	0.72	0.03	MBO
4666	Dietz	2011 06/18-06/20	17.8	252	19	2.9540	0.0004	0.24	0.01	PHO
5131	1990 BG	2009 11/22-2010 01/10	32.1,22.8	127	0	76.9	0.1	0.22	0.03	NEO
5209	Oloosson	2011 02/10-02/11	8.4	99	6	14.6	0.1	0.50	0.05	TRO-J
5496	1973 NA	2011 01/01-01/02	14.0	108	17	2.86	0.01	0.00	0.01	NEO
5496	1973 NA	2011 06/09-06/12	76.0	314	23	2.856	0.002	0.15	0.02	NEO
5621	Erb	2011 08/30-09/01	20.1	1	9	8.027	0.006	0.09	0.01	MC
5626	Melissabrucker	2009 07/01-07/31	18.6,4.2	310	4	2.4857	0.0002	0.06	0.01	NEO
5682	Beresford	2011 10/22-10/23	1.8	31	1	3.771	0.005	0.07	0.01	MC
5736	Sanford	2011 07/13-07/15	23.7	272	28	3.1850	0.0011	0.35	0.03	PHO
5736	Sanford	2011 07/28	27.8	275	29	3.185	0.001	0.41	0.02	PHO
7002	Bronshten	2011 10/29-11/01	3.0	39	-3	2.672	0.002	0.13	0.02	MC
7750	McEwen	2011 08/20-08/29	20.0	340	25	27.843	0.003	0.45	0.01	MBO
7757	Kameya	2011 07/13-07/16	25.6	303	33					PHO
7784	Watterson	2011 09/08-10/13	*23.1,24.5	347	27	2.5392	0.0002	0.08	0.01	PHO
12225	Yanfernandez	2011 05/08-05/13	6.5	234	7	33.7	0.3	0.17	0.01	MBO
13819	1999 SX5	2011 03/04-03/05	8.0	153	11	2.592	0.006	0.10	0.03	MC
14335	Alexosipov	2011 10/14-10/15	18.6	356	-2	7.201	0.012	0.10	0.01	MBO
14764	Kilauea	2011 06/22-06/23	21.2	246	25			1.2	0.1	HUN
15673	Chetaev	2011 10/29-11/04	16.3	45	8	102.	1.	0.69	0.02	MC
17744	Jodiefoster	2011 08/06-08/08	7.7	321	5	73.	4.	0.39	0.02	MC
18081	2000 GB126	2011 04/21-04/22	13.9	193	22	8.289	0.006	0.32	0.02	PHO
18882	1999 YN4	2010 12/07-12/08	26.1	88	32	2.466	0.009	0.12	0.01	NEO
19379	Labrecque	2012 02/01	10.2	126	15	2.60	0.02	0.10	0.01	PHO
23183	2000 OY21	2011 03/01	32.4	136	35	6.98	0.01	0.71	0.02	NEO
23552	1994 NB	2012 04/04-04/08	25.8	168	28	3.630	0.002	0.48	0.02	PHO
24475	2000 VN2	2011 12/24	38.4	66	7					NEO
27810	Daveturner	2011 02/09-02/16	7.7	136	8					HUN
29168	1990 KJ	2011 05/15-05/16	16.3	229	25	2.588	0.003	0.15	0.02	PHO
30019	2000 DD	2011 10/22-10/24	7.8	28	11	5.487	0.005	0.11	0.02	HUN
30722	Biblioran	2014 11/22-12/01	3.9	49	14	2.8695	0.0002	0.24	0.01	MBO
31425	1999 BF3	2011 04/16-04/17	11.3	218	13	9.04	0.07	0.08	0.02	MBO
32802	1990 SK	2011 11/02-11/04	8.2	50	-1	2.4276	0.0014	0.11	0.01	PHO
32906	1994 RH	2012 01/27-01/31	17.0	122	16	2.6411	0.0006	0.11	0.02	NEO
34759	2001 QL151	2011 01/22-01/27	28.0	109	37	12.219	0.003	0.30	0.02	MC
36284	2000 DM8	2011 02/02-02/04	10.6	148	2	3.844	0.002	0.22	0.02	NEO
41434	2000 GB82	2011 10/24-10/28	3.0	35	0	4.1335	0.0013	0.14	0.01	MC
43750	1981 QG3	2011 06/17-06/29	20.6	254	24	12.621	0.003	0.30	0.02	MBO
44262	1998 QR51	2011 01/13-01/17	18.3	114	25	68.	1.	0.6	0.1	PHO
47035	1998 WS	2012 02/27	27.6	133	31	4.02	0.01	0.11	0.01	MC
47035	1998 WS	2012 03/07-03/10	28.2	136	28	3.9970	0.0007	0.14	0.01	MC
47035	1998 WS	2012 04/06-04/07	30.6	146	18	3.987	0.003	0.27	0.02	MC
54660	2000 UJ1	2009 11/09	38.6	24	5	5.44	0.03	1.20	0.02	NEO
55854	Stoppani	2011 04/25-04/26	7.0	216	10	3.0638	0.0012	0.33	0.02	HUN
66008	1998 QH2	2010 09/02-09/03	13.9	358	-8	6.241	0.015	0.19	0.02	NEO
75079	1999 VN24	2011 04/06-04/12	8.0	189	9	6.632	0.002	0.15	0.02	MC
77645	2001 KX66	2011 04/30-05/12	22.5	230	30	3.6134	0.0004	0.14	0.03	PHO
81298	2000 GW1	2011 06/24-06/28	27.2	249	33	10.3378	0.0012	1.09	0.03	PHO
85953	1999 FK21	2011 03/26-04/05	5.1,33.8	180	6			0.6	0.1	NEO
103067	1999 XA143	2010 01/10-01/16	18.8	129	5	9.87	0.01	0.47	0.03	NEO
136617	1994 CC	2009 09/24-09/27	36.6	32	11	2.382	0.003	0.08	0.03	NEO
138524	2000 OJ8	2011 09/02-09/04	29.9	359	14	2.6814	0.0012	0.06	0.02	NEO
141018	2001 WC47	2012 04/17	50.9	183	17					NEO

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). D is the diameter (km, *diameter is from JPL SBN). Other diameters were derived from *H* and p_V values. The last column gives the a/b ratio, based on the amplitude, for an assumed triaxial ellipsoid viewed equatorially.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
143487	2003 CR20	2009 09/21-09/28	46.1,22.7	23	-3	7.021	0.004	0.19	0.03	NEO
152664	1998 FW4	2009 09/21-09/23	15.8	350	0	17.19	0.0.11	0.23	0.01	NEO
159402	1999 AP10	2009 09/21-09/23	5.0	158	6	7.919	0.005	0.30	0.01	NEO
159402	1999 AP10	2009 12/18-12/20	14.5	170	8	7.922	0.004	0.41	0.01	NEO
159402	1999 AP10	2010 01/10	13.4	171	8	7.92	0.01	0.36	0.02	NEO
160092	2000 PL6	2011 10/09-10/11	29.2	26	33	3.0176	0.0009	0.17	0.02	NEO
163081	2002 AG29	2011 10/22-10/24	3.7	30	2	19.85	0.03	0.23	0.02	NEO
178783	2001 BY2	2011 01/28-01/30	5.8	122	-5	59.	1.	0.66	0.05	MC
181882	1999 RF14	2011 03/02-03/11	12.0	148	7					MC
188174	2002 JC	2011 05/13-05/21	78.5	227	52	2.4719	0.0002	0.33	0.02	NEO
218863	2006 WO127	2009 10/12-2010 01/10	8.9,66.4	25	-17	210.	5.	0.7	0.1	NEO
222073	1999 HY1	2009 10/22-10/23	13.0	40	4	5.18	0.04	0.16	0.03	NEO
241370	2008 LW8	2010 06/09-06/10	26.6	236	14	10.83	0.16	0.03	0.01	NEO
253841	2003 YG118	2011 02/14	62.0	185	8	3.43	0.04	0.16	0.02	NEO
274138	2008 FU6	2011 04/12	8.5	196	4	2.66	0.04	0.05	0.01	NEO
276741	2004 EM66	2011 04/13-04/15	13.1	214	6	4.573	0.004	0.13	0.02	MC
302831	2003 FH	2011 10/30-11/01	64.9	8	26	13.97	0.02	0.98	0.03	NEO
307190	2002 EK130	2011 08/05-08/07	6.8	317	7	8.25	0.04	0.11	0.02	MC
307544	2003 EJ16	2010 03/24	12.0	167	2	3.99	0.12	0.04	0.01	MC
326683	2002 WP	2009 11/12-11/26	34.0	51	-22	6.2632	0.0008	1.65	0.03	NEO
351545	2005 TE15	2009 09/21-09/26	19.1,9.7	8	-7	10.610	0.005	0.52	0.03	NEO
366833	2005 MC	2009 11/24-11/26	63.0	106	33	9.33	0.06	0.35	0.03	NEO
385343	2002 LV	2009 07/13-07/15	43.5	272	34	6.20	0.01	0.74	0.03	NEO
387632	2002 PD40	2010 04/26	30.6	198	30	2.815	0.009	0.16	0.01	MC
387632	2002 PD40	2010 07/03-07/10	46.0	236	41	2.8133	0.0002	0.23	0.01	MC
407656	2011 SL102	2011 12/25-12/27	31.0	84	19	25.	1.	1.4	0.1	NEO
420187	2011 GA55	2011 08/30-08/31	8.0	334	6	2.575	0.001	0.14	0.02	NEO
448972	2011 VY15	2012 03/11-03/12	11.3	180	2	2.851	0.004	0.09	0.01	NEO
451397	2011 EZ78	2011 05/27-06/07	44.0	255	33	3.115	0.001	0.42	0.05	NEO
483504	2002 XN14	2009 12/18-12/20	25.2	71	-2	18.02	0.13	0.24	0.02	NEO
523654	2011 SR5	2011 09/20-09/22	29.2	349	15	10.07	0.02	0.21	0.02	NEO
524196	2001 QP181	2011 04/25-04/30	15.0	205	2			0.4	0.1	NEO
530520	2011 LT17	2011 06/11	56.0	252	29	1.284	0.007	0.16	0.03	NEO
612050	1997 GL3	2010 09/05-09/06	25.3	357	10					NEO
	2000 CP101	2011 08/21	80.0	292	28	10.	2.	1.0	0.2	NEO
	2009 MC9	2009 09/21-09/26	27.8	340	10	4.789	0.002	0.93	0.03	NEO
	2009 NH	2009 07/30-07/31	16.0	318	5	3.024	0.005	0.17	0.03	NEO
	2009 WV25	2009 11/25	13.0	59	5	2.92	0.07	0.92	0.05	NEO
	2011 CG2	2011 02/06-02/09	8.5	137	-5	10.798	0.004	1.35	0.05	NEO
	2011 CY46	2011 03/09-03/11	52.0	168	30	5.5663	0.0008	0.57	0.03	NEO
	2011 GM62	2011 04/22	55.0	213	28	8.	2.			NEO
	2011 GP59	2011 04/11	33.0	213	12	0.12250	0.00001	1.97	0.15	NEO
	2011 HS	2011 04/26-04/27	50.0	216	29			2.	0.1	NEO
	2011 KE	2011 05/23-05/24	29.0	249	17	8.02	0.02	0.50	0.04	NEO
	2011 LJ19	2011 09/18	38.0	342	16	6.69	0.01	0.46	0.03	NEO
	2011 LJ19	2011 09/19	32.0	347	15	6.69	0.01	0.61	0.02	NEO
	2011 LJ19	2011 09/24	21.0	0	12	6.69	0.01	0.44	0.02	NEO
	2011 MD	2011 06/25	64.0	261	30	0.19372	0.00009	0.79	0.06	NEO
	2011 MD	2011 06/26	63.3	261	29	0.19372	0.00004	0.83	0.04	NEO
	2011 OQ5	2011 09/22	7.5	358	6	5.92	0.03	0.20	0.01	NEO
	2011 PT1	2011 09/29	28.5	16	15	8.3	0.2	0.08	0.03	NEO

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LIGHTCURVE ANALYSIS FOR THREE MAIN BELT ASTEROIDS

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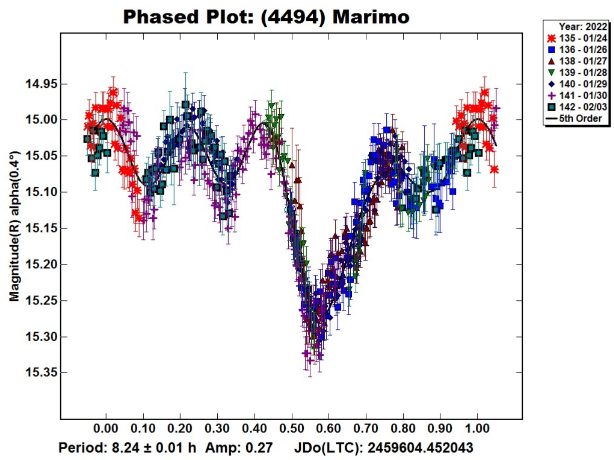
Photometric observations of three main-belt asteroids 4494 Marimo, 5516 Jawilliamson, and (57754) 2001 VW12, were made at the Filzi School Observatory (School in country Laives - Italy) MPC Station D12.

CCD photometric observations, were made at the Filzi School Observatory, all are without filter (clear). All images were obtained with a 0.35-m reflector telescope reduced to *f*/8.0, a QHY9 CCD camera, and calibrated with dark and flat-field frames. The pixel scale was 1.56 arcsec when binned at 4×4 pixels. All exposures were 120 seconds. The computer clock was synchronized with an Internet time server before each session. Differential photometry and period analysis were done using *MPO Canopus* version 10.7.12.9 (Warner, 2018). Solar type stars from CMC15 catalog in R band were used as comparison stars.

4494 Marimo. This main-belt asteroid was reported as a lightcurve photometry opportunity for 2022 January on the MinorPlanet.info web site (*https://www.minorplanet.info/php/callopplcdbquery.php*; hereafter referenced as MPI). It was discovered in 1988-10-13 by Ueda and Kaneda at Kushiro. It is a main-belt asteroid with a semi-major axis of 2.34 AU, eccentricity 0.12, inclination 2.47 deg, and orbital period of 3.58 yr. Its absolute magnitude is H= 13.68 mag. It was observed for seven nights (January-February 2022), the derived synodic period is P = 8.24 ± 0.01 h with an amplitude of A = 0.22 ± 0.05 mag. The lightcurve is asymmetric multimodal. There were no entries in the LCDB (Warner et al., 2009) for this asteroid.



Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
4494	Marimo	2022 01/24-02/03	0.5 5.5	124.6	-0.7	8.24	0.01	0.22	0.05	MB
5516	Jawilliamson	2022 03/22-03/27	5.5 4.9	185.9	7.0	5.153	0.002	0.17	0.04	MB
57754	2001 VW12	2022 08/03-08/24	13.8 10.2	326.9	13.2	9.772	0.001	0.77	0.04	MB

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).