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New and updated convex shape models of asteroids based on optical data from a large collaboration network

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ABSTRACT

Context. Asteroid modeling efforts in the last decade resulted in a comprehensive dataset of almost 400 convex shape models and their rotation states. These efforts already provided deep insight into physical properties of main-belt asteroids or large collisional families. Going into finer detail (e.g., smaller collisional families, asteroids with sizes ≲20 km) requires knowledge of physical parameters of more objects.

Aims. We aim to increase the number of asteroid shape models and rotation states. Such results provide important input for further studies, such as analysis of asteroid physical properties in different populations, including smaller collisional families, thermophysical modeling, and scaling shape models by disk-resolved images, or stellar occultation data. This provides bulk density estimates in combination with known masses, but also constrains theoretical collisional and evolutional models of the solar system.

Methods. We use all available disk-integrated optical data (i.e., classical dense-in-time photometry obtained from public databases and through a large collaboration network as well as sparse-in-time individual measurements from a few sky surveys) as input for the convex inversion method, and derive 3D shape models of asteroids together with their rotation periods and orientations of rotation axes. The key ingredient is the support of more that 100 observers who submit their optical data to publicly available databases.

Results. We present updated shape models for 36 asteroids, for which mass estimates are currently available in the literature, or for which masses will most likely be determined from their gravitational influence on smaller bodies whose orbital deflections will be observed by the ESA *Gaia* astrometric mission. Moreover, we also present new shape model determinations for 250 asteroids, including 13 Hungarias and three near-Earth asteroids. The shape model revisions and determinations were enabled by using additional optical data from recent apparitions for shape optimization.

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

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[†] Deceased.

1. Introduction

Asteroid modeling efforts in the last decade resulted in an extensive dataset of almost 400 convex shape models and rotation states (see the review by Ďurech et al. 2015a). The majority of these models was determined by the lightcurve inversion method (LI) developed by Kaasalainen & Torppa (2001) and Kaasalainen et al. (2001). About 100 models are based on disk-integrated, dense-in-time optical data (e.g., Torppa et al. 2003; Slivan et al. 2003; Michałowski et al. 2005; Marciniak et al. 2009, 2011). Combining dense-in-time data with sparse-in-time measurements from large sky surveys, or using only sparse-in-time data, increased the number of available shape models by a factor of 4 (Ďurech et al. 2009; Hanuš et al. 2011, 2013a,c). Future data from *Gaia*, Panoramic Survey Telescope and Rapid Response System (PanSTARRS), and Large Synoptic Survey Telescope (LSST) should result in an increase of shape models by an order of at least one magnitude (Ďurech et al. 2005). The methods that will be used for analysis of these future data of unprecedented amount and quality, by the means of complex shape modeling, are similar to those applied here and developed within the scope of our recent studies.

Most asteroid shape models derived by the LI method and their optical data are available in the Database of Asteroid Models from Inversion Techniques (DAMIT[1]; Ďurech et al. 2010).

We would like to emphasize and acknowledge that the shape modeling stands on the shoulders of hundreds of observers, often amateurs, who regularly obtain photometric data with their small and mid-sized telescopes. These observations have significantly contributed to the great progress of the shape modeling field in the last decade. Although there is much more sparse than dense data available, the latter will always remain important because their much higher photometric accuracy and rotation coverage leads to higher quality shape models. This is a typical example of the great interaction between the professional and amateur community (Mousis et al. 2014).

Knowing the rotational parameters and shapes of asteroids is very important for numerous applications. The large amount of currently known asteroid models already provided a deep insight into physical properties of main-belt asteroids (MBAs) and large collisional families: (i) an excess of prograde rotators within (MBAs) larger than ∼50 km in diameter, predicted by numerical simulations (Johansen & Lacerda 2010), was confirmed by Kryszczyńska et al. (2007), Hanuš et al. (2011); (ii) an excess of retrograde rotators within near-Earth asteroids (NEAs) is consistent with the fact that most of the NEAs come from the ν_6 resonance (La Spina et al. 2004). To enter the ν_6 resonance via Yarkovsky effect[2], the object must be a retrograde rotator; (iii) an anisotropy of spin-axis directions of MBAs asteroids with diameters $\lesssim$30 km and NEAs was revealed and explained by the YORP effect[3], collisions, and mass shedding (Hanuš et al. 2011; Pravec et al. 2012); (iv) a bimodality of prograde and retrograde rotators symmetric with respect to the center of the family is caused by the combined Yarkovsky, YORP, and collisional dynamical evolution (Kryszczyńska 2013; Hanuš et al. 2013a); (v) the larger dispersion of spin-axis directions of smaller ($D \lesssim 50$ km) prograde than retrograde asteroids suggests that spin states of prograde rotators are affected by resonances (Hanuš et al. 2013c); or (vi) the disruption of asteroid pairs[4] was most likely the outcome of the YORP effect that spun up the original asteroid (Polishook 2014).

With the use of convex shape models in combination with asteroidal stellar occultations and disk-resolved images obtained by space telescopes or ground-based telescopes equipped with adaptive optics (AO) systems, the size of the model can be constrained, making it possible to determine the asteroid volume. Even when the object is considerably nonconvex, the scaled convex model from occultations and AO data tends to compensate by average fitting to the disk-resolved data. As a result, the overestimation of the volume is smaller than would correspond to the convex hull. The volume can then provide, in combination with mass estimates, realistic values of bulk densities (Ďurech et al. 2011; Hanuš et al. 2013b).

The mass is one of the most challenging parameters to measure for an asteroid. Mass estimates are now available for 280 asteroids, but only 113 of these are more precise than 20% (Carry 2012; Scheeres et al. 2015). However, the situation is expected to improve significantly in the near future. The observations of the ESA *Gaia* astrometric satellite will provide masses accurate to better than 50% for ≈150 asteroids (and for ≈50 with an accuracy better than 10%; Mouret et al. 2007, 2008) by the orbit deflection method. The advantage of the masses determined by *Gaia* is in the uniqueness of the mission: we should obtain a comprehensive sample with well-described biases (e.g., the current mass estimates are currently strongly biased toward the inner main belt).

To maximize the possible outcome by means of density determinations, we focus on determination of shape models for asteroids for which accurate mass estimates are available or will most likely be determined by *Gaia*. Moreover, it is also important to update shape models for such asteroids using recently obtained optical data. By doing this, we can provide better constraints on the rotational phase (i.e., on the asteroid orientation, which is important for scaling the size) of these asteroids due to the improvement of the rotation period, and more accurate rotation state and shape parameters.

Convex models, together with thermal infrared observations, have also been used as inputs for thermophysical modeling, enabling the determination of geometric visible albedo, size, and surface properties (e.g., Müller et al. 2011; Hanuš et al. 2015). This application is particularly important because it can make use of the large sample of infrared data for more than 100 000 asteroids acquired by the NASA's Wide-field Infrared Survey Explorer (WISE). The missing input here is shape models of sufficient quality (Delbo et al. 2015).

Moreover, convex models or at least rotational states are usually necessary inputs for more complex shape modeling, which can be performed if additional data, such as stellar occultations, AO images or interferometry containing information about the nonconvexities, (Kaasalainen & Viikinkoski 2012; Carry et al. 2010a,b, 2012; Viikinkoski et al. 2015; Tanga et al. 2015) are available.

Finally, large flat areas/facets on convex shape models, represented by polyhedra, usually indicate possible concavities

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[1] `http://astro.troja.mff.cuni.cz/projects/asteroids3D`

[2] A thermal recoil force affecting rotating asteroids (Bottke et al. 2001).

[3] Yarkovsky–O'Keefe–Radzievskii–Paddack effect, a torque caused by the recoil force from anisotropic thermal emission, can alter the rotational periods and orientation of spin axes; see, e.g., Rubincam (2000), Vokrouhlický et al. (2003).

[4] An asteroid pair consists of two unbound objects with almost identical heliocentric orbital elements that were originally part of a bound system.

(Devogèle et al. 2015). Candidates for highly irregular bodies can be identified for further studies.

In Sect. 2, we introduce the dense- and sparse-in-time optical disk-integrated data, which we used for the shape model determinations. We describe the lightcurve (convex) inversion method in Sect. 3, present updated and new shape model determinations in Sects. 4.1 and 4.2, comment on several individual solutions in Sect. 4.3, and conclude our work in Sect. 5.

2. Optical disk-integrated photometry

Similar to Hanuš et al. (2011, 2013a,c), we use two different types of optical disk-integrated data: (i) dense-in-time photometry, i.e., classical continuous multihour observations; and (ii) sparse-in-time photometry consisting of a few hundred individual calibrated measurements from several astrometric observatories, typically covering ~15 years.

Dense photometry was acquired from publicly available databases, from those of our collaborators, or directly from several individual observers. The historical data from the second half of the twentieth Century are mainly stored in the Asteroid Photometric Catalogue (APC[5]; Piironen et al. 2001). Currently, the common practice, which is used mostly by observers from the United States, is a regular data submission to the Minor Planet Center in the Asteroid Lightcurve Data Exchange Format (ALCDEF[6]; Warner et al. 2011). These data are publicly available and often also published in the Minor Planet Bulletin[7], where the synodic rotation period is reported. Many European observers send their data to the Courbes de rotation d'astéroïdes et de comètes database (CdR[8]), maintained by Raoul Behrend at Observatoire de Genève. Composite lightcurves with best-fitting synodic rotation periods are then published on the web page.

We obtained the first type of sparse-in-time photometric data for this study from the AstDyS site (Asteroids – Dynamic Site[9]) and processed the data according to Hanuš et al. (2011). We solely employ sparse data from the USNO-Flagstaff station (IAU code 689) and the Catalina Sky Survey Observatory (IAU code 703, Larson et al. 2003), weighting them with respect to dense data (unity weight) by 0.3 and 0.15, respectively. As an alternative to this type of sparse-in-time data, we use the Lowell Photometric Database (Oszkiewicz et al. 2011; Bowell et al. 2014). The photometry from several astrometric surveys, including both USNO-Flagstaff and Catalina Sky Survey, reported to the Minor Planet Center (MPC), was reprocessed; e.g., systematic effects in the magnitude calibration were removed. This enormous dataset typically consists of several hundreds of individual measurements for each of the ~320 000 asteroids that were processed so far. Although the accuracy of the recalibrated photometry is improved, the dataset for each asteroid is still a mixture of measurements from several observatories with different photometric quality. Compared to the data of USNO-Flagstaff and Catalina observatories downloaded from AstDyS, Lowell data provide an increased quantity of measurements from more observing geometries. These data, however, are, on average, of poor photometric quality, as they also contain measurements from observatories that were originally rejected in Hanuš et al. (2011) owing to low accuracy. We assigned to Lowell data the weight of 0.1. A subset of Lowell data was already analyzed by Ďurech et al. (2013) and a complex analysis of the reliability of shape models, based solely on these data, is underway (Ďurech et al. 2016). On top of that, the volunteer project Asteroids at home[10], which makes use of distributed computing and runs in the framework of Berkeley Open Infrastructure for Network Computing (BOINC), currently employs shape model computations based on Lowell data (Ďurech et al. 2015b). Thousands of individual home computational stations of volunteers are currently participating in the project.

Tables 1 and A.1 include the information about the optical data used for the shape model determination, such as the number of dense-in-time lightcurves and apparitions covered by dense-in-time observations and the number of sparse-in-time measurements from corresponding astrometric surveys. Table A.2 provides references to the dense data used for the shape model determinations and Table A.3 links the observers to their observatories.

3. Convex inversion and reproducibility

In this work, we use the lightcurve inversion method of Kaasalainen & Torppa (2001) and Kaasalainen et al. (2001), which is already a well-documented, investigated, and employed technique for asteroid shape modeling (for more details, see the review by Ďurech et al. 2015a).

The main advantage of using convex inversion is that convex models are usually the only stable or unambiguous inversion result (Ďurech & Kaasalainen 2003); they best portray the resolution level or information content of disk-integrated photometry. To demonstrate this more intuitively, consider an asteroid with a large planar region (or many regions) on the surface (e.g., an ellipsoid with a sizable chunk or chunks chopped off), and a large crater (say, half the size of the plane) at one end of the plane. Then it is impossible to tell from lightcurve data (no matter how large solar phase angles, i.e., shadows) where the crater is in the plane, or whether it is two craters half the size, or even myriads of small craters on the surface that have the same combined area as the big one (even if the crater filled most of the plane). In other words, one simply cannot say whether the lightcurves are caused just by small-scale surface roughness on a convex shape, or by huge nonconvexities that would be obvious in any disk-resolved data. Hence, any nonconvex model from disk-integrated photometric data is inevitably ambiguous, while the convex model is unambiguous. This also explains why the assumption of the nonconvexity represented by a large plane in the convex model (e.g., Devogèle et al. 2015), while often a good guess because of physical constraints, cannot usually be more than an assumption.

Convex inversion was successfully used for shape model determinations of almost 400 asteroids. On top of that, several convex models were validated by disk-resolved and delay-Doppler images or by direct comparison with images obtained by space probes (e.g., Kaasalainen et al. 2001; Carry et al. 2012). The parameter space of shape, rotation period, spin vector orientation, and scattering properties (simple three-parameter empirical model) is systematically investigated in the means of a χ^2-metric

$$\chi^2 = \sum_i \frac{\left\| L^{(i)}_{\mathrm{OBS}} - L^{(i)}_{\mathrm{MOD}} \right\|}{\sigma_i^2}, \tag{1}$$

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[5] `http://asteroid.astro.helsinki.fi/`

[6] `http://www.minorplanet.info/alcdef.html`

[7] `http://www.minorplanet.info/minorplanetbulletin.html`

[8] `http://obswww.unige.ch/~behrend/page_cou.html`

[9] `http://hamilton.dm.unipi.it/`

[10] `https://asteroidsathome.net/`

Table 1. Rotational states and summary of used photometry for asteroids for which we updated their shape models based on new disk-integrated optical data.

Asteroid	λ_1 [deg]	β_1 [deg]	λ_2 [deg]	β_2 [deg]	P [h]	$N_{\rm lc}$	$N_{\rm app}$	$N_{\rm LOW}$	Original model published by
3 Juno	104	20			7.209532	38	11	332	Kaasalainen et al. (2002)
7 Iris	19	19	198	5	7.138843	39	14	372	Kaasalainen et al. (2002)
16 Psyche	32	−7			4.195948	118	19	567	Kaasalainen et al. (2002)
17 Thetis	240	22			12.26603	57	10	690	Ďurech et al. (2009)
19 Fortuna	96	56			7.44322	48	11	565	Torppa et al. (2003)
20 Massalia	304	76	124	81	8.09759	36	9	380	Kaasalainen et al. (2002)
22 Kalliope	196	4			4.148201	102	17	343	Kaasalainen et al. (2002)
23 Thalia	159	−40			12.31241	50	12	466	Torppa et al. (2003)
27 Euterpe	82	44	265	39	10.40193	54	6		Stephens et al. (2012)
29 Amphitrite	136	−20			5.390119	66	15	323	Kaasalainen et al. (2002)
39 Laetitia	322	30			5.138238	68	26	448	Kaasalainen et al. (2002)
40 Harmonia	22	34			8.90848	23	7	405	Hanuš et al. (2011)
41 Daphne	199	−30			5.98798	33	8	508	Kaasalainen et al. (2002)
42 Isis	113	45			13.58364	31	8	499	Hanuš et al. (2011)
45 Eugenia	125	−34			5.699151	101	16	574	Hanuš et al. (2013b)
54 Alexandra	152	19			7.02264	38	8	506	Warner et al. (2008b)
64 Angelina	135	6	315	5	8.75171	24	4	450	Ďurech et al. (2011)
76 Freia	138	12	319	17	9.97306	57	12	463	Marciniak et al. (2012)
87 Sylvia	82	64			5.183641	55	12	545	Kaasalainen et al. (2002), Berthier et al. (2014)
88 Thisbe	82	69			6.04132	28	8	554	Torppa et al. (2003)
94 Aurora	65	9	242	−7	7.22619	22	8	550	Marciniak et al. (2011)
95 Arethusa	119	23			8.70221	15	2	417	Ďurech et al. (2011)
107 Camilla	72	51			4.843928	34	10	543	Torppa et al. (2003)
110 Lydia	148	−39	340	−57	10.92581	53	11	398	Ďurech et al. (2007)
121 Hermione	1	16			5.550881	48	9	536	Descamps et al. (2009)
129 Antigone	211	55			4.957160	52	11	535	Torppa et al. (2003)
130 Elektra	176	−89			5.224663	56	13	358	Ďurech et al. (2007)
354 Eleonora	162	43			4.277184	64	13	482	Hanuš et al. (2011)
360 Carlova	3	56	143	67	6.18959	9	4	435	Ďurech et al. (2009)
372 Palma	234	−5	51	54	8.57964	38	8	406	Hanuš et al. (2011)
386 Siegena	289	25			9.76503	83	12	460	Marciniak et al. (2012)
409 Aspasia	2	28			9.02145	22	8	438	Warner et al. (2008b), Hanuš et al. (2013b)
423 Diotima	351	4			4.775377	58	12	540	Ďurech et al. (2007)
511 Davida	298	22			5.129365	58	17	588	Torppa et al. (2003)
532 Herculina	100	9			9.40494	74	11	410	Kaasalainen et al. (2002)
776 Berbericia	346	25			7.66701	59	11	402	Ďurech et al. (2007)

Notes. We also provide the reference to the original model and in two cases to the plausible non-convex model as well. The table gives ecliptic coordinates λ_1 and β_1 of the best-fitting pole solution, ecliptic coordinates λ_2 and β_2 for the possible second (mirror) pole solution, sidereal rotational period P, the number of dense lightcurves $N_{\rm lc}$ spanning $N_{\rm app}$ apparitions, the number of sparse-in-time measurements from Lowell $N_{\rm LOW}$, and the reference to the original model.

where the ith brightness measurement $L^{(i)}_{\rm OBS}$ (with an uncertainty of σ_i) is compared to the corresponding modeled brightness $L^{(i)}_{\rm MOD}$. The best-fitting parameter set is searched for.

A significant minimum in the parameter space indicates a unique solution. Visual examination of the fit in the period subspace is performed as well as the comparison between observed and modeled lightcurves. Additionally, the pole-ecliptic latitudes should be similar within the two pole solutions, which are typically determined as a result of the ambiguity (symmetry) presented in most lightcurve inversion models (Kaasalainen & Lamberg 2006). On the other hand, the pole-ecliptic longitudes of these so-called mirror solutions should differ by ~180 degrees. The pole ambiguity is present in the majority of our shape models.

Moreover, we also compute the principal moments of inertia of each shape model, assuming a homogeneous mass distribution, and compare these moments with the moment of inertia along the rotation axis. A reliable solution should rotate within ~10–20 degrees of the axis with the largest moment of inertia.

If available, we use a priori information about the rotation period of the asteroid from the Minor Planet Lightcurve Database[11] (Warner et al. 2009) to significantly reduce, usually by at least two orders of magnitude, computation requirements. Hence, we investigate the parameter space only in the proximity of the expected rotation period.

It should be kept in mind that none of the shape models should be taken as granted, i.e., each asteroid model contains an uncertainty (both in shape and rotation state), which increases with decreasing amount, variety, and quality of the optical data. It was already shown in Hanuš et al. (2015) that by varying a shape model within its uncertainty, one can obtain significantly different fits to the thermal infrared data by the thermophysical modeling. Thus, the shape uncertainty plays an important role for the interpretation of the thermal infrared data. This demonstrates the need of accounting for the shape model uncertainties

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[11] `http://cfa-www.harvard.edu/iau/lists/Lightcurve\discretionary-Dat.html`

in all further shape model applications. Also, the overall shape model based mostly on sparse data usually contains many flat facets (areas) with rather sharp edges, thus most of the low-detail topography is hidden (i.e., we have a large uncertainty in the shape). As we use more dense data, the shape becomes smoother and has more details. This limits the application of the lower-resolution shape models based mostly on sparse data.

In the ecliptic coordinate frame, the typical pole direction uncertainties are: (i) $\lesssim 5^\circ$ in latitude β and $\lesssim 5^\circ/\cos\beta$ in longitude λ for asteroid models based on large multiapparition dense lightcurve datasets; (ii) $\sim 5{-}10^\circ$ in β and $\sim 5{-}10^\circ/\cos\beta$ in λ for models based on combined multiapparition dense data and sparse-in-time measurements; and finally; (iii) $\sim 10{-}30^\circ$ in β and $\sim 10{-}30^\circ/\cos\beta$ in λ for models based on combined few-apparition dense data with sparse-in-time measurements or only sparse-in-time data.

To sum up, we follow the same procedure for the shape model determinations as in Hanuš et al. (2011, 2013a,c). Finally, we would like to emphasize that our work can be easily reproduced by anyone who is interested. The LI code and the lightcurve data are available in DAMIT, as well as the user manual.

4. Results and discussions

4.1. Updated shape models

We updated shape models of 36 asteroids with known mass estimates or for which masses will be most likely determined by the orbit deflection method from the *Gaia* astrometric observations (Mouret et al. 2007, 2008, and personal communication with François Mignard). For each one of these asteroids, there were new available optical dense data (see Table A.2). We combined these new data with Lowell data and the already available dense photometry from DAMIT. If applicable, we replaced the original sparse data from AstDyS with the Lowell data.

In most cases, rotational states of updated shape models are similar to those of the original models in the DAMIT database. The only exceptions, which we individually commented on in Sect. 4.3, are asteroids (27) Euterpe, and (532) Herculina. We performed the LI independently from any previous shape modeling results (e.g., we did not use information about the spin axis).

Updated models provide better constraints on the rotational phase, thus these models allow us, for example, to better link recently obtained AO and occultation profiles with the orientation of the shape model at the time of the observation. This is essential for a potential scaling of the sizes of shape models to compute the volume, and consequently bulk densities. Obviously, the uncertainties in rotation period, spin axis direction, and shape model should be improved as there are more data used for the modeling.

Optimized rotation state parameters and information about optical data are listed in Table 1. References to the optical dense-in-time data can be found in Table A.2.

4.2. New shape models

The majority of our new shape model determinations is obtained by combining dense-in-time data with sparse-in-time measurements from the Lowell database. However, the fact that Lowell data contain for each asteroid a mixture of measurements from several observatories makes it difficult to find a representative weight with respect to the dense data. Indeed, a specific single value of the weight can result in an overestimation for some asteroids, while it can underestimate others. Despite these issues, we decided to use a weight of 0.1 for the Lowell data as a whole and to present corresponding shape models. As a consequence, we sometimes obtained a unique shape solution if we combined dense data and the sparse data from AstDyS (i.e., from USNO and Catalina), but not if we used the Lowell data instead. We present these shape models as well.

Moreover, 57 out of 250 shape models are based only on sparse data from USNO-Flagstaff and Catalina Sky Survey observatories. That these models can nevertheless be reliable was already shown in Hanuš & Ďurech (2012) and Hanuš et al. (2013c). As suggested there, we ran the LI search for shape and rotation state parameters with two different shape resolutions: (i) standard one; and (ii) lower one, which serves as a test of the solution stability. For this case, the asteroid's synodic rotation period is also available in the Minor Planet Lightcurve Database (LCDB, Warner et al. 2009), an additional test for the reliability can be performed. A rotation period derived by the LI (a period interval of 2–1000 h is typically scanned), which matches that already reported, points to a secure solution. In practice, all shape solutions based solely on sparse data that fulfilled our stability tests had rotation periods in an agreement with synodic periods from LCDB. This also demonstrates that our other unique solutions, for which a previous period estimate is not available, are reliable. We present nine of these shape and rotation state solutions; these are labeled in Table A.1.

We present shape models of three NEAs, which all have negative values of their pole latitudes β, and obliquities larger than 90°. The fact that they all show retrograde rotation supports the consensus that about half of the NEAs migrated through the ν_6 secular resonance, which causes an observed excess of retrograde rotators (La Spina et al. 2004).

We further present shape models of 13 asteroids that are classified as Hungarias. The majority of them (10 out of 13) exhibit retrograde rotation, which is in an agreement with the findings of Warner et al. (2014), who reported, in a sample of 53 Hungarias, a 75% representation of retrograde rotators.

Thirty-one of the derived shape models are those asteroids whose density will be measured in future or was already obtained. While for some of them, estimations on their masses are already available, the masses of the others will be determined from *Gaia* astrometric measurements. Constraining the model sizes of these asteroids using disk-resolved images, stellar occultation data, or thermophysical modeling will directly facilitate estimation of bulk densities.

Rotation state parameters and information about used optical data for all new shape model determinations are listed in Table A.1. References to the optical dense-in-time data can be found in Table A.2.

4.3. Individual asteroids

(27) Euterpe. The lightcurve amplitude of this asteroid is very low ($\lesssim$0.1 mag) and the dense data cover multiple apparitions. Thus, we decided to exclude the Lowell data from the shape modeling because they were dominated by noise. Our derived rotation period (10.40193 h) is slightly different than that derived by Stephens et al. (2012) (10.40825 h), which resulted in a different pole solution of $(\lambda, \beta) = (82, 44)^\circ$ and $(\lambda, \beta) = (265, 39)^\circ$ for the mirror solution. The solution in longitude λ is similar to that of Stephens et al. (2012), but their latitude has a different sign (−39 and −30, respectively).

(532) Herculina. Our (single) pole solution only differs by ∼180° in longitude λ from that reported by Kaasalainen et al. (2002), thus it corresponds to their mirror solution. In contrast to their solution, our model is based on additional data from 2005 and 2010 apparitions.

(537) Pauly. The rotation period of 14.15 h from the LCDB is in contradiction with our shape modeling result: our period of 16.2961 h fits the data significantly better and thus is preferred.

(596) Scheila. The observations taken on December 11th, 2010 with the Catalina Schmidt telescope exhibited a comet-like appearance (Larson 2010). This behavior was later confirmed by Jewitt et al. (2011) from the HST observations on December 27th, 2010 and on January 4th, 2011 and interpreted as caused most likely by a collision with a 35m asteroid. All photometric data used for the shape modeling date prior to this event, so the shape model does not reflect any potential changes in the shape, period, or spin orientation induced by the collision (Bodewits et al. 2014).

(8567) 1996 HW_1. The shape model of this NEAs was already determined by Magri et al. (2011) from a combination of dense lightcurves and radar Doppler images. We derived a consistent shape model and rotational state solution from combined dense and sparse data. The main difference between these two models is the fact that the Doppler images contain nonconvex signatures that were translated into their shape model. Even if our shape model is purely convex, it reliably represents the overall shape of the real asteroid. This case once again demonstrates the reliability of the convex inversion method.

(9563) Kitty. We derived the shape model of this asteroid without knowledge of a previous period estimate. However, Chang et al. (2015) recently reported period $P = 5.35 \pm 0.03$ h based on the optical data from the Intermediate Palomar Transient Factory that is in perfect agreement with our independent determination of $P = 5.38191 \pm 0.00005$ h.

5. Conclusions

In this work, we updated shape models of 36 asteroids with mass estimates by including new optical dense-in-time data in the shape modeling. For 250 asteroids, including 13 Hungarias and three NEAs, we derived their convex shape models and rotation states from combined disk-integrated dense- and sparse-in-time photometric data or from only sparse-in-time data. This effort was achieved with the help of the community of ∼100 individual observers who shared their lightcurves. All new models are now included in the DAMIT database and are available to anyone for additional studies. For nine asteroids, we provide, together with shape models and pole orientations, their first rotation period estimates.

Our work is a typical example in which a contribution of hundreds of observers, who are regularly obtaining photometric data with their small and mid-sized telescopes, was necessary to achieve presented results. The initial motivation of the observers is to derive the synodic rotation period (sometimes this is an object of a publication in the Minor Planet Bulletin), however, the shape modeling provides a welcome additional opportunity for the usage of their optical data. We acknowledge all the observers who submit their observations to the public databases and invite others to do so as well. This practice allows us an easy and straightforward access to the data and largely avoids an overlook of the precious data.

The shape models can be used as inputs for various studies, such as spin-vector analysis, detection of concavities, thermophysical modeling with the varied-shape approach by Hanuš et al. (2015), nonconvex modeling, size optimization by disk-resolved images or occultation data, or density determinations.

Shape models based only on sparse data (or combined with a few dense lightcurves) are convenient candidates for follow-up observations, both to confirm the rotation periods and to improve the shape models, which is necessary, e.g., for thermophysical modeling. Finally, we maintain a web page with a list of asteroids, for which mass estimates are available and the shape model determination still requires additional photometric data (Hanuš 2015). These objects are candidates for accurate density determination and any lightcurve support is welcome.

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Appendix A: Additional tables

Table A.1. New asteroid shape model determinations from disk-integrated optical data.

	Asteroid	λ_1 [deg]	β_1 [deg]	λ_2 [deg]	β_2 [deg]	P [h]	N_{lc}	N_{app}	N_{689}	N_{703}	N_{LOW}
	Near-Earth asteroids										
3752	Camillo	256	−14			37.881	9	1			77
5332	1990 DA	266	−21			5.80285	6	3			190
8567	1996 HW1	283	−34			8.76239	45	2			333
	Hungarias										
434	Hungaria	109	67			26.4879	40	5			331
1103	Sequoia	60	−59			3.037976	13	3			320
2001	Einstein	87	−43			5.48503	13	4			382
2495	Noviomagum	12	−57			6.65168	4	1			190
3266	Bernardus	227	−32			10.75954	15	4			321
4490	Bambery	53	59			5.82345	15	5			323
4764	Joneberhart	219	−36			5.48411	8	3			313
6087	Lupo	248	−16			4.71654	7	2		78	
6517	Buzzi	227	−75			8.64468	17	4			337
7660	1993 VM1	321	−44			5.91818	8	2			333
11058	1991 PN10	234	−64			6.51669	7	2		96	
67404	2000 PG26	149	69			5.39877	7	2			275
86257	1999 TK207	28	−60			32.4029	13	2			201
	Main-belt asteroids										
12	Victoria[a]	174	−17			8.66034	53	8			352
18	Melpomene[a]	11	14			11.57031	64	8			326
24	Themis[a]	331	52	137	59	8.37419	46	7			713
26	Proserpina	88	−52			13.10977	29	7			563
31	Euphrosyne[a]	88	66	290	6	5.529597	29	8			366
35	Leukothea	15	7	196	0	31.9009	52	7			417
36	Atalante	45	−49	190	−55	9.92692	30	6			369
48	Doris[a]	297	61	108	47	11.89010	31	4			591
51	Nemausa[a]	169	−62	347	−68	7.78484	60	17			446
56	Melete[a]	103	−27	282	−5	18.1482	37	6			400
66	Maja	49	−70	225	−68	9.73570	16	5			436
71	Niobe	88	−33			35.8521	49	7			426
98	Ianthe[a]	286	18			16.4801	9	2			382
99	Dike	233	50			18.1191	29	4			410
103	Hera	85	24	270	40	23.7427	29	3			516
104	Klymene[a]	112	2	292	−4	8.98059	12	3			519
112	Iphigenia[a]	101	−66	286	−50	31.4625	7	1			416
117	Lomia[a]	312	−40	117	−18	9.12417	19	4			459
120	Lachesis[a]	256	39	82	55	46.5508	35	4			467
122	Gerda	201	22	23	20	10.68724	17	6			553
136	Austria	117	53	357	81	11.49662	4	1			401
144	Vibilia[a]	248	56	54	48	13.82516	43	4			417
150	Nuwa[a]	359	25	177	22	8.13456	33	5			543
154	Bertha[a]	28	34	234	32	25.2285	18	3			431
155	Scylla	201	69	356	53	7.95880	7	1	110	108	
164	Eva	54	−10			13.66380	18	4			390
171	Ophelia	144	29	329	23	6.66454	37	4			453
179	Klytaemnestra[a]	65	−6	248	−9	11.17342	3	1			391
180	Garumna	41	−64	196	−64	23.8592	23	2			467
187	Lamberta[a]	153	−56	328	−62	10.66703	20	5			482
189	Phthia[a]	26	35	197	45	22.3416	15	3	135	60	
210	Isabella[a]	100	−14	278	−26	6.67190			176	64	
212	Medea[a]	40	−24	220	−33	10.28414	46	8			397
226	Weringia	284	−14			11.14849	24	4			485
233	Asterope	132	36	322	59	19.6981	13	3			427
237	Coelestina	42	14	230	30	29.1758	10	1			366
245	Vera	265	−51	96	−50	14.35651	3	1			351
246	Asporina	235	−10	47	−36	16.25222	6	1			438
247	Eukrate	103	−22			12.09480	41	3			315
249	Ilse	3	85	222	41	84.995	29	3			461

Notes. The table provides ecliptic coordinates λ_1 and β_1 of the best-fitting pole solution, ecliptic coordinates λ_2 and β_2 for the possible second (mirror) pole solution, sidereal rotational period P, the number of dense lightcurves N_{lc} spanning N_{app} apparitions, and the number of sparse-in-time measurements from three sources: N_{689} (USNO-Flagstaff), N_{703} (Catalina Sky Survey) and N_{LOW} (Lowell). [(a)] Reliable mass estimate exists or the mass will be most likely detetermined from Gaia astrometric measurements. [(b)] First rotation period estimate.

Table A.1. continued.

Asteroid	λ_1 [deg]	β_1 [deg]	λ_2 [deg]	β_2 [deg]	P [h]	N_{lc}	N_{app}	N_{689}	N_{703}	N_{LOW}
254 Augusta	179	−52	25	−53	5.89505	6	2			371
263 Dresda	99	54	272	61	16.8139	12	4			605
270 Anahita	15	−50	207	−59	15.05906	12	4			492
271 Penthesilea	225	49	42	53	18.7875	7	1	129	83	
274 Philagoria	328	−71	154	−65	17.9410	12	3			460
287 Nephthys	356	36	158	39	7.60411	8	3	291	90	
293 Brasilia	103	−7	274	−34	8.17410	4	1			411
296 Phaetusa	146	53	330	52	4.53809	5	1			340
313 Chaldaea[a]	219	34	45	10	8.38993	21	5			390
315 Constantia	162	56	353	45	5.34750	3	1	49	115	
317 Roxane	220	−62	40	−70	8.16961	16	2			504
327 Columbia	52	43	238	26	5.93183			161	108	
343 Ostara	103	64	294	48	110.028	13	2			348
353 Ruperto-Carola	183	−58	43	−64	2.738963	6	1	106	80	
361 Bononia	294	13	115	45	13.80634	5	2	183	73	
365 Corduba[a]	255	33	80	4	12.7054	49	5			446
381 Myrrha[a]	219	72	37	43	6.57196	10	4			496
389 Industria	98	−38	291	−29	8.49520	9	3			505
391 Ingeborg	354	−65			26.4146	24	2			409
394 Arduina	195	−61	56	−79	16.6217	8	1			395
402 Chloe	312	−49	160	−37	10.66844	13	3			375
407 Arachne	241	−63	43	−58	22.6263	5	1			433
419 Aurelia[a]	0	48	174	42	16.8	47	9			
455 Bruchsalia[a]	242	−13	73	−21	11.8401	15	2			429
474 Prudentia	301	−54	136	−64	8.57227	5	1			374
480 Hansa	352	18	173	−32	16.1894	8	3	200	64	
482 Petrina	281	61	94	24	11.79214	42	5			337
489 Comacina	265	−16	88	−43	9.02321	5	3			434
490 Veritas[a]	56	34	231	43	7.92811	10	1			435
497 Iva	121	−22	303	−32	4.620850	8	2			359
502 Sigune	178	−36			10.92666	23	3			378
520 Franziska	282	−79	114	−45	16.5045	9	2			384
526 Jena	5	36	183	48	9.51664	3	1	151	44	
537 Pauly	31	32	211	51	16.2961	7	3			472
562 Salome	78	41	275	28	6.35031	9	3			425
564 Dudu	73	−51	213	−36	8.88504	3	1			327
565 Marbachia	334	−22	163	−47	4.58782	7	2			452
567 Eleutheria	317	33	131	53	7.71743	19	4			395
586 Thekla	232	36	55	32	13.6816	3	1			432
596 Scheila[a]	264	−18	89	−9	15.8666	7	1	153	76	
622 Esther	248	−60			47.5039	5	1			431
625 Xenia	307	9	122	7	21.0122	3	1			415
632 Pyrrha	74	−72	253	−74	4.11686	5	1			487
639 Latona	204	10	25	12	6.19127	5	2	160	42	
644 Cosima	278	−31	100	−30	7.55709	16	2			461
660 Crescentia	68	11	236	49	7.91036	18	3			438
670 Ottegebe	128	75			10.03991	4	1			540
681 Gorgo	310	−50	150	−50	6.46063	4	1			319
682 Hagar	56	−78	255	−57	4.85042	6	1			334
686 Gersuind	125	53	260	58	6.31240	5	1			400
687 Tinette	271	18	100	43	7.39710	3	1			297
692 Hippodamia	233	−53			8.99690	3	1			396
698 Ernestina	213	−66	76	−49	5.03660			140	76	
706 Hirundo	92	66	244	54	22.0160	6	1			365
742 Edisona	46	−54	175	−43	18.5833	15	3	141	115	
746 Marlu	202	−66	64	−27	7.78887	11	2			373
749 Malzovia	55	46	246	55	5.92748	5	1			423
756 Lilliana	201	31	53	36	7.83250	21	4			372
757 Portlandia	263	−69	90	−56	6.58112	12	2			566
758 Mancunia[a]	111	48	306	44	12.72011	26	3			461
762 Pulcova[a]	194	−42	17	−14	5.83977	8	2			408
784 Pickeringia[a]	282	35	103	68	13.16998	1	1			437
797 Montana	6	61	179	45	4.54619			145	124	
798 Ruth	84	27			8.55068	18	5			426
802 Epyaxa	347	−87			4.39012	4	2	92	50	
830 Petropolitana	217	36	34	41	37.347			151	51	

Table A.1. continued.

Asteroid	λ_1 [deg]	β_1 [deg]	λ_2 [deg]	β_2 [deg]	P [h]	N_{lc}	N_{app}	N_{689}	N_{703}	N_{LOW}
856 Backlunda	42	44	226	73	12.02894	2	1	155	103	
870 Manto	96	30	283	35	122.166	44	2			363
872 Holda	77	24	253	32	5.94052	12	2	169	77	
873 Mechthild	249	−52	51	−61	11.00639	9	2			391
877 Walkure	262	71	47	66	17.4217	3	1			596
881 Athene	115	−77	338	−43	13.8943			92	89	
908 Buda	40	5	225	16	14.57498	6	2			303
928 Hildrun	247	−29	86	−63	14.1163			146	114	
944 Hidalgo	277	16	-999	-999	10.05822	15	4	0	0	99
986 Amelia	80	30	282	30	9.51856	4	1	147	110	
898 Hildegard	344	27	164	8	24.8544	15	2	0	0	242
1010 Marlene	299	42	106	47	31.0651	8	1			364
1021 Flammario[a]	32	22	216	55	12.15186	10	2			368
1023 Thomana	86	−65	272	−42	17.5611	8	1			486
1080 Orchis	255	27	71	28	16.0657	13	1			447
1110 Jaroslawa	236	75			97.278	50	2			307
1119 Euboea	79	75	282	55	11.3981			132	147	
1125 China	132	−46	305	−49	5.36863	2	1			357
1135 Colchis	139	−58	330	−81	23.4830			142	97	
1137 Raissa	220	−66	40	−77	143.644	33	2			408
1150 Achaia	169	−69	347	−62	61.072			67	98	
1175 Margo	184	−43	353	−17	6.01375	4	1			395
1192 Prisma	133	−78			6.55836	5	1			193
1204 Renzia	142	−50	305	−45	7.88695	1	1			528
1244 Deira	314	−46	107	−56	216.98	21	1			331
1278 Kenya	164	−66	281	−77	187.60	27	1			466
1310 Villigera	3	63	240	26	7.83001	4	1			319
1312 Vassar	251	−23			7.93190	4	1			317
1352 Wawel	200	59	32	61	16.9543	5	1			356
1360 Tarka	323	−55			8.86606	10	2			242
1366 Piccolo	352	49	201	55	16.1834	9	3	136	110	
1368 Numidia	201	−62			3.640739	3	1	129	83	
1424 Sundmania	51	76	275	58	94.537	16	1			490
1430 Somalia	297	42	128	47	6.90907	6	1			409
1449 Virtanen	307	58	99	58	30.5005	11	1			354
1459 Magnya	72	−59	207	−51	4.67911			137	96	
1486 Marilyn	88	−66	267	−66	4.56695	5	1			492
1508 Kemi	352	108	166	73	9.19182	6	2	0	0	246
1534 Nasi	82	23	268	13	7.93161	3	1			362
1546 Izsak	124	32	322	60	7.33200	3	1	80	80	
1621 Druzhba	240	71			99.100	1	1			365
1648 Shajna	117	54	306	53	6.41369			75	136	
1665 Gaby	261	41	66	32	67.911	1	1			296
1672 Gezelle	45	79			40.6824	12	2			366
1676 Kariba	74	74	281	60	3.167338	3	1			342
1730 Marceline	264	68	82	44	3.836544	2	1			268
1735 ITA	39	−46	178	−52	12.6103			148	107	
1746 Brouwer	21	−67	158	−71	19.7255	4	1	88	64	
1750 Eckert	176	60	-999	-999	377.5	23	1	0	0	193
1772 Gagarin	183	22	358	5	10.93791	3	1	46	110	
1789 Dobrovolsky	319	30	137	34	4.811096	3	2			380
1793 Zoya	238	64	62	64	5.751872	5	2			398
1816 Liberia	73	−68			3.086156			86	104	
1820 Lohmann	264	65	69	55	14.0449	16	1			281
1825 Klare	2	−58			4.74288	5	1			336
1837 Osita	36	−52	228	−58	3.81880	4	1			337
1838 Ursa	42	64	284	29	16.1635			102	91	
1892 Lucienne	26	−40	213	−61	9.31556	1	1			286
1902 Shaposhnikov	326	37	144	79	20.9959	15	4			459
1925 Franklin−Adams	277	57	66	48	2.978301	2	1			270
1946 Walraven	259	−80	80	−59	10.2101			101	73	
2306 Bauschinger	0	−64	225	−65	21.6704	6	1		63	
2313 Aruna	80	−75			8.88620				103	
2358 Bahner	360	57	193	52	10.8528	13	1		69	
2381 Landi	220	−36	14	−66	3.986041	6	1			364
2382 Nonie	205	52			15.1117	7	2			354

Table A.1. continued.

Asteroid		λ_1 [deg]	β_1 [deg]	λ_2 [deg]	β_2 [deg]	P [h]	N_{lc}	N_{app}	N_{689}	N_{703}	N_{LOW}
2393	Suzuki	80	53	222	38	9.2875				92	
2659	Millis	109	−49	288	−48	6.12464	2	1			566
2713	Luxembourg	164	4	343	4	3.58132				97	
2725	David Bender	198	−37	58	−57	9.95798	3	1	37	115	
2741	Valdivia	269	−31	103	−59	4.09668	4	1			482
2785	Sedov	206	48	26	54	5.47761				127	
2791	Paradise	100	−16			9.80729	3	1		40	
2802	Weisell	255	−50	112	−63	37.705			27	156	
2948	Amosov	267	−64	33	−73	7.39889				120	
2962	Otto	230	−58			2.53632				111	
3247	Di Martino	53	−70	231	−75	5.44517				87	
3258	Somnium	119	−47	274	−71	5.33803	7	1			567
3285	Ruth Wolfe	142	33			3.93494	3	1		75	
3301	Jansje	361	28	173	40	9.42533	8	1			630
3428	Roberts	63	49	231	49	3.27835			24	129	
3455	Kristensen	9	10	186	10	8.09218				129	
3478	Fanale	95	64	297	62	3.244843	5	1			627
3544	Borodino	294	−60	157	−57	5.43460	7	2			515
3693	Barringer	243	−43			6.62564				81	
3725	Valsecchi	77	−54	242	−53	3.56973				83	
3773	Smithsonian	257	−51	81	−50	6.98132	5	1			622
3786	Yamada	84	52	218	48	4.03295	3	1			463
3787	Aivazovskij	75	59	238	57	2.980807				138	
3918	Brel	71	58	238	47	3.09679	1	1		114	
4080	Galinskij	209	−74			7.35845				162	
4265	Kani	106	60	310	54	5.72755	4	1			730
4284	Kaho	6	−21	193	0	4.05763				79	
4554	Fanynka	220	55	64	63	4.77502				84	
4570	Runcorn	123	57	287	31	20.1514	11	1		87	
4917	Yurilvovia^b	224	20	48	1	4.17744				90	
5008	Miyazawakenji^b	144	−52	322	−25	49.239				101	
5111	Jacliff	259	−45			2.83990				107	
5208	Royer	258	74	54	37	3.88494				138	
5231	Verne	175	−45	359	−88	4.32058			20	76	
5317	Verolacqua	224	−51			3.02181				119	
5489	Oberkochen	195	−41	13	−66	5.62439	3	1			470
5596	Morbidelli	173	−80			5.40043				78	
5776	1989 UT2^b	360	−72			4.34079				133	
6000	United Nations	13	−84			3.26191			21	143	
6026	Xenophanes^b	266	−54	80	−56	3.78170				100	
6192	1990 KB1	61	67	239	75	78.631	16	2		91	
6406	1992 MJ	20	−63	221	−55	6.81818	3	1			508
6410	Fujiwara	243	−85			7.00669	2	1			552
6755	Solov'yanenko	224	54	47	58	8.1680				101	
6905	Miyazaki	33	7	214	−4	2.733348				120	
7233	Majella	298	−87	80	−71	3.81240				77	
8043	Fukuhara^b	96	−41			22.7606				117	
8860	Rohloff^b	37	−58			18.8411				114	
9542	Eryan^b	200	−5	21	−22	2.79473				120	
9563	Kitty	272	−28	91	−34	5.38191				111	
10064	1988 UO^b	78	−45	240	−57	12.1277				122	
14197	1998 XK72	192	−74	38	−62	10.6453	4	1			441
16173	2000 AC98	37	−48	209	−37	6.48550				97	
16468	1990 HW1^b	119	−84			94.13	1	1		72	
18487	1996 AU3	245	−45	91	−70	6.59077				120	
28736	2000 GE133	249	−52	134	−84	4.65442	3	1		118	
28887	2000 KQ58	182	−35	354	−78	6.84315	6	1			368
31060	1996 TB6	216	−66	74	−39	5.10432				108	
32776	Nriag	239	−59	102	−76	3.98679				141	
33116	1998 BO12	244	69	45	54	6.34669	4	1		122	
34484	2000 SR124	116	−59	268	−80	6.17516				99	
42923	1999 SR18	46	69			8.3889				155	

Table A.2. New observations used for updating the shape models and observations that are not included in the UAPC used for new shape model determinations.

Asteroid	Date	$N_{\rm LC}$	Observer
3 Juno	2013 09 – 2013 09	1	Maurice Audejean
7 Iris	2010 12 – 2010 12	2	Gérald Rousseau
	2013 08 – 2013 08	1	Patrick Sogorb
16 Psyche	2003 05 – 2003 05	2	Eric Barbotin
	2003 05 – 2003 05	2	Laurent Bernasconi
17 Thetis	2007 04 – 2007 04	1	Arnaud Leroy
	2011 02 – 2011 02	3	Ramón Naves
	2011 03 – 2011 03	1	Quentin Déhais
19 Fortuna	2011 04 – 2011 04	1	Ramón Naves
	2011 04 – 2011 04	2	Gérald Rousseau
20 Massalia	2012 03 – 2012 05	13	David Higgins
	2012 06 – 2012 06	2	Frederick Pilcher
22 Kalliope	2004 06 – 2004 06	2	Alain Klotz
	2004 06 – 2004 06	3	René Roy, Raoul Behrend
	2004 06 – 2012 02	10	René Roy
	2006 11 – 2006 11	4	Hiromi Hamanowa, Hiroko Hamanowa
	2006 12 – 2006 12	1	Jean-François Coliac
	2007 02 – 2007 03	5	Enric Forné
	2007 02 – 2007 03	9	Warner (2007a)
	2007 03 – 2007 03	1	Arnaud Leroy, Sylvain Bouley Guillaume Dubos, Raoul Behrend
	2007 03 – 2007 03	1	Ramón Costa
	2012 01 – 2012 01	4	Emmanuel Conseil
	2012 02 – 2012 02	1	Jacques Montier
	2012 02 – 2012 02	1	Jean-François Colliac
	2012 02 – 2012 02	1	Maurice Audejean
23 Thalia	2009 08 – 2009 09	8	Pilcher (2010f)
	2010 12 – 2011 01	3	Gérald Rousseau
	2011 01 – 2011 02	4	Ramón Naves
	2015 02 – 2015 02	1	Greg Tumolo, Veronika Afonina Alexander Scholz, Sharat Jawahar
27 Euterpe	2000 07 – 2011 08	43	Stephens et al. (2001), Stephens (2001), Stephens et al. (2012)
	2010 06 – 2010 07	5	Pilcher (2011c)
	2010 07 – 2010 07	1	Jacques Montier, Serge Heterier
29 Amphitrite	2006 10 – 2006 11	9	Hiromi Hamanowa, Hiroko Hamanowa
	2007 11 – 2007 11	1	Enric Forné
	2008 02 – 2008 02	1	Polishook (2009)
	2009 04 – 2009 04	2	Arnaud Stiepen, Olivier Wertz Davide Ricci, Yassine Damerdji René Giraud, Raoul Behrend
	2009 04 – 2009 04	2	Jean-François Pirenne, Pierre Piron Damien Renauld, Lucas Salvador Benjamin Vanoutryve, Raoul Behrend
	2009 04 – 2009 04	2	Mathieu Waucomont, Alice Decock Sophie Delmelle, Maïte Dumont Thomas Fauchez, Raoul Behrend
	2009 04 – 2009 04	2	Olivier Adam, Arnaud Collet Benjamin Modave, Niyonzima Innocent Raoul Behrend
	2012 02 – 2012 02	3	François Kugel, Jérôme Caron
39 Laetitia	1998 03 – 1998 03	1	Yurij Krugly
	2003 03 – 2003 03	1	Claudine Rinner
	2003 03 – 2003 03	1	Stéphane Charbonnel
	2004 05 – 2005 07	4	Josep Coloma
	2010 10 – 2010 11	3	Ramón Naves
	2012 02 – 2012 02	2	Maurice Audejean
40 Harmonia	2003 01 – 2003 01	1	Alain Klotz
	2003 05 – 2003 05	3	Laurent Bernasconi
	2008 12 – 2010 06	10	Pilcher (2009a, 2010b)
41 Daphne	2001 11 – 2001 11	4	Laurent Bernasconi
42 Isis	2011 01 – 2011 02	5	René Roy
45 Eugenia	1998 12 – 1999 01	2	Federico Manzini, Raoul Behrend
	1998 12 – 2005 06	5	Federico Manzini
	2005 06 – 2005 07	3	Matthieu Conjat
	2007 11 – 2009 05	15	Marchis et al. (2010)
	2010 07 – 2010 07	1	René Roy

Table A.2. continued.

Asteroid	Date	N_{LC}	Observer
	2014 05 – 2014 06	3	Jean-Paul Teng, André Peyrot Alain Klotz, Raoul Behrend
	2014 06 – 2014 06	2	Ramón Naves
	2014 06 – 2014 06	2	Romain Montaigut, Arnaud Leroy Raoul Behrend
	2014 06 – 2014 06	3	Nicolas Esseiva, Raoul Behrend
54 Alexandra	2005 06 – 2005 06	5	Jean-Paul Teng, Raoul Behrend
	2006 12 – 2007 01	5	Michael Fauerbach
	2007 02 – 2007 02	2	Stéphane Fauvaud, Marcel Fauvaud Jean-Marie Vugnon
	2008 01 – 2008 01	5	Warner et al. (2008b)
	2009 03 – 2009 05	8	Higgins & Warner (2009)
64 Angelina	2005 01 – 2005 01	3	Laurent Bernasconi
76 Freia	2005 09 – 2005 09	1	Pierre Antonini
	2000 09 – 2000 10	6	Shevchenko et al. (2008)
	2007 12 – 2007 12	3	Stephens & Warner (2008)
	2009 03 – 2009 03	2	Christophe Demeautis
	2012 06 – 2012 07	6	Emmanuel Jehin, Jean Manfroid Michael Gillon
	2014 12 – 2015 04	5	Nicolas Esseiva, Raoul Behrend
	2015 04 – 2015 04	3	Robin Esseiva, Nicolas Esseiva Raoul Behrend
88 Thisbe	2007 01 – 2007 01	1	René Roy
	2012 02 – 2012 02	4	Maurice Audejean
94 Aurora	2010 03 – 2010 03	1	Raymond Poncy
95 Arethusa	2006 07 – 2006 07	4	Laurent Bernasconi
	2006 08 – 2006 08	1	Jean-Gabriel Bosch
	2006 08 – 2006 08	4	Raymond Poncy
107 Camilla	2004 09 – 2004 11	2	Laurent Bernasconi
	2008 05 – 2008 06	3	Polishook (2009)
	2010 07 – 2010 07	1	Fabien Reignier
	2010 07 – 2010 07	2	Jacques Montier, Serge Heterier
110 Lydia	2003 12 – 2003 12	11	Pray (2004a)
	2003 12 – 2012 10	5	Stephens & Warner (2013)
	2006 06 – 2006 06	2	Roberto Crippa, Federico Manzini
	2008 12 – 2015 05	8	Maurice Audejean
	2012 10 – 2014 01	6	Warner (2014b)
121 Hermione	2003 12 – 2003 12	1	Laurent Brunetto
	2003 12 – 2003 12	1	Philippe Baudouin
	2003 12 – 2004 02	4	René Roy
	2004 01 – 2004 01	1	Stefano Sposetti
	2004 01 – 2004 01	2	Jean Lecacheux, François Colas
	2004 02 – 2004 02	2	Federico Manzini
	2004 02 – 2005 02	4	Laurent Bernasconi
	2007 03 – 2007 09	19	Descamps et al. (2009)
	2009 11 – 2009 11	4	Robert Buchheim
	2011 01 – 2011 02	3	Jérôme Caron
129 Antigone	2004 02 – 2004 03	4	Josep Coloma, Raoul Behrend
	2005 01 – 2005 01	1	Yassine Damerdji
	2005 04 – 2005 04	2	René Roy
	2010 05 – 2010 05	1	John Ruthroff
	2010 05 – 2010 05	5	Axel Martin
	2010 06 – 2010 07	3	Jérôme Caron
130 Elektra	2009 12 – 2009 12	1	Pére Antoni Salom, Mateu Esteban Raoul Behrend
	2011 03 – 2011 03	3	Jacques Montier, Raoul Behrend
	2011 04 – 2011 04	1	Giovanni Casalnuovo, B. Chinaglia
	2011 04 – 2011 04	1	Giovanni Casalnuovo
354 Eleonora	2001 04 – 2001 04	1	Stefano Sposetti
	2002 06 – 2002 06	2	Silvano Casulli
	2006 06 – 2006 06	1	Hilari Pallares
	2006 06 – 2006 06	2	Josep Coloma
	2006 07 – 2006 08	4	Enric Forné
	2011 05 – 2011 05	3	Etienne Morelle, Raoul Behrend
	2011 05 – 2011 05	3	Maurice Audejean
	2011 05 – 2011 05	4	Giovanni Casalnuovo, B. Chinaglia
	2011 05 – 2011 05	1	Giovanni Casalnuovo

Table A.2. continued.

Asteroid	Date	N_{LC}	Observer
360 Carlova	2012 01 – 2012 02	3	Maurice Audejean
372 Palma	2005 08 – 2005 08	2	Pierre Antonini
	2005 08 – 2005 09	5	Laurent Bernasconi
	2011 09 – 2011 10	4	Eric Barbotin
386 Siegena	2007 02 – 2007 03	7	Stephens (2007c)
409 Aspasia	2004 02 – 2004 02	1	Laurent Bernasconi
	2008 01 – 2008 01	5	Warner et al. (2008b)
	2008 02 – 2008 02	1	Arnaud Leroy
	2008 02 – 2008 02	1	Christophe Demeautis
	2008 02 – 2008 02	1	Jean-François Coliac
	2010 10 – 2010 11	3	Raymond Poncy
423 Diotima	2005 01 – 2005 01	1	Roger Dymock
	2009 11 – 2009 11	3	Maurice Audejean
	2009 11 – 2009 11	4	Pére Antoni Salom, Mateu Esteban
511 Davida	2005 06 – 2005 06	2	Reiner Stoss, Jaime Nomen Salvador Sanchez, Raoul Behrend
	2010 05 – 2010 06	6	Maurice Audejean
	2010 06 – 2010 06	3	Joe Garlitz
	2015 04 – 2015 04	1	Christophe Gillier
	2015 04 – 2015 04	1	Inna Bozhinova, Alexander Scholz Alex Hygate
	2015 04 – 2015 05	2	René Roy, Raoul Behrend
	2015 04 – 2015 05	1	René Roy
	2015 05 – 2015 05	1	David Romeuf
	2015 05 – 2015 05	1	Pierre Antonini, Raoul Behrend
	2015 05 – 2015 05	1	Pierre Antonini
532 Herculina	2005 01 – 2005 04	4	Josep Coloma
	2005 02 – 2005 02	1	Hilari Pallares
	2010 04 – 2010 04	1	Florian, Corentin Titouan, Raoul Behrend
	2010 05 – 2010 05	1	Jacques Montier, Jean-Pierre Previt
	2010 05 – 2010 05	2	René Roy
	2010 05 – 2010 06	3	Maurice Audejean
	2010 06 – 2010 06	1	Jacques Montier, Serge Heterier Jean-Pierre Previt
776 Berbericia	2003 11 – 2003 11	2	Pray (2004a)
	2005 02 – 2005 02	2	Federico Manzini
	2005 03 – 2005 03	2	Laurent Bernasconi
	2006 06 – 2010 03	8	Stephens (2010b)
	2008 12 – 2008 12	2	Mateu Cerda, Pére Antoni Salom
	2010 02 – 2010 04	11	Axel Martin
	2015 03 – 2015 03	2	René Roy
	2015 04 – 2015 04	1	David Romeuf
New models			
12 Victoria	2000 10 – 2000 10	9	López-Gonzáles
	2010 07 – 2010 07	1	René Roy, Raoul Behrend
	2010 07 – 2010 07	3	Donn Starkey
	2011 11 – 2011 11	1	André Debackère, Loïc Chalamet Carine Fournel, Raoul Behrend
	2011 11 – 2011 11	2	Anna Marciniak
	2012 02 – 2012 02	1	Maurice Audejean, Raoul Behrend
	2012 02 – 2012 02	5	Maurice Audejean
	2013 01 – 2013 03	7	Pilcher (2013d)
18 Melpomene	2012 08 – 2014 01	16	Pilcher (2013a, 2014a)
	2012 07 – 2012 08	3	Ewa Kosturkiewicz, Waldemar Ogłoza Marek Dróżdż
	2012 07 – 2012 07	5	Stefano Mottola
24 Themis	2012 10 – 2014 04	9	Pilcher (2013c, 2014c)
	2011 11 – 2011 11	1	Toni Santana-Ros
26 Proserpina	2007 12 – 2009 06	11	Pilcher (2008c, 2013b)
	2010 07 – 2010 07	1	Axelle Spiridakis, Tanguy Déléage André Debackére, Raoul Behrend
	2010 08 – 2010 08	2	Jacques Montier
	2010 09 – 2010 09	2	Pierre Antonini
	2012 03 – 2012 03	2	Anna Marciniak, Toni Santana-Ros
31 Euphrosyne	2008 04 – 2013 04	18	Pilcher & Jardine (2009), Pilcher (2012a, 2013b)
	2011 09 – 2011 09	1	Pierre Farissier

Table A.2. continued.

Asteroid	Date	N_{LC}	Observer
	2011 10 – 2011 10	1	Arnaud Leroy
35 Leukothea	2004 12 – 2004 12	6	Laurent Bernasconi
	2007 10 – 2010 02	40	Pilcher (2008a), Pilcher & Jardine (2009), Pilcher (2010c)
	2012 09 – 2012 09	3	Maurice Audejean
36 Atalante	1978 08 – 1978 08	1	David Higgins
	2007 02 – 2012 04	11	Gérald Rousseau
	2007 03 – 2007 03	2	Warner (2007a)
	2007 03 – 2008 06	3	Brinsfield (2007a)
	2010 10 – 2010 09	6	Pierre Antonini
48 Doris	2009 05 – 2009 06	8	Higgins & Pilcher (2009)
	2010 07 – 2010 07	1	Jacques Montier, Serge Heterier Raoul Behrend
	2010 07 – 2010 08	3	Gérald Rousseau
	2010 07 – 2010 09	3	Jacques Montier, Serge Heterier
	2010 08 – 2010 08	1	Arnaud Leroy
	2010 08 – 2010 08	1	Romain Montaigut, Rémi Anquetin Pierre Barroy, Bruno Mallecot
	2010 08 – 2010 09	6	Pierre Antonini
51 Nemausa	2007 03 – 2007 03	1	Josef Hanus, Marek Wolf
	2008 08 – 2012 09	6	Maurice Audejean
	2009 10 – 2009 10	1	Pére Antoni Salom, Mateu Esteban
	2011 05 – 2011 06	13	Axel Martin
	2014 03 – 2014 03	1	Pierre Aurard, Thomas Dulcamara Lucas Berard, Bryan Baduel Marine Lutz, Gwendoline Séné Emilia Splanska, Olivier Labrevoir Raoul Behrend
56 Melete	2003 05 – 2003 05	6	Laurent Bernasconi
	2007 04 – 2007 05	8	Warner (2007b)
	2008 10 – 2008 11	8	Pilcher & Jardine (2009)
	2012 09 – 2012 11	4	Maurice Audejean
66 Maja	2007 03 – 2007 03	1	Jean-Gabriel Bosch
	2009 08 – 2011 04	8	Maurice Audejean
	2011 01 – 2011 01	1	Jérôme Caron
71 Niobe	2006 02 – 2006 03	14	Warner et al. (2006)
	2009 11 – 2010 03	13	Pilcher (2010a)
98 Ianthe	2007 10 – 2007 11	5	Pilcher (2008b)
99 Dike	2007 03 – 2007 04	6	Jean-Gabriel Bosch
	2007 04 – 2007 04	1	Enric Forné
	2007 04 – 2007 04	9	Axel Martin
	2011 03 – 2011 04	8	Pilcher (2011a)
103 Hera	2010 06 – 2010 11	19	Pilcher & Higgins (2011)
	2010 07 – 2010 07	1	David Higgins
104 Klymene	2011 04 – 2011 04	2	Gérald Rousseau
	2011 05 – 2011 05	3	Stefano Mottola
112 Iphigenia	2007 10 – 2007 12	7	Pilcher (2008b)
117 Lomia	2003 03 – 2003 03	1	Nathanal Berger
	2003 03 – 2003 03	2	Claudine Rinner
	2003 03 – 2003 03	3	René Roy
	2003 03 – 2003 04	3	Stéphane Charbonnel
	2006 11 – 2006 11	3	Raymond Poncy
	2013 03 – 2013 03	4	Maurice Audejean
120 Lachesis	2008 12 – 2012 09	30	Pilcher (2009c)
122 Gerda	2005 08 – 2005 09	3	Buchheim (2007)
	2006 12 – 2006 12	2	Raymond Poncy
	2008 02 – 2008 02	2	Hervé Jacquinot
	2009 04 – 2009 04	3	Pilcher (2009a)
	2011 11 – 2011 11	2	René Roy
144 Vibilia	2006 12 – 2006 12	3	René Roy
	2011 01 – 2011 01	1	Arnaud Leroy
	2011 01 – 2011 02	6	Pierre Antonini
	2011 12 – 2012 04	16	Stephan Hellmich
	2012 03 – 2012 04	4	Krzysztof Sobkowiak, Roman Hirsch Toni Santana-Ros
150 Nuwa	2005 01 – 2005 01	3	Laurent Bernasconi
	2006 02 – 2006 02	3	Raymond Poncy
	2009 10 – 2009 10	1	Sergison

Table A.2. continued.

Asteroid	Date	N_{LC}	Observer
	2009 10 – 2009 10	2	Mendicini
	2009 10 – 2009 10	2	Vincent
	2009 10 – 2009 11	4	Crow
	2009 10 – 2009 11	7	Miles
	2009 11 – 2009 11	1	Faillace
	2010 12 – 2011 01	5	Pilcher (2011d)
	2011 02 – 2011 02	2	René Roy
154 Bertha	2006 11 – 2006 11	1	Raymond Poncy
	2007 01 – 2007 01	5	Warner (2007a)
	2011 09 – 2011 10	10	Pilcher (2012a)
155 Scylla	2008 11 – 2008 12	7	Pilcher & Jardine (2009)
164 Eva	2008 05 – 2008 06	6	Warner (2009b)
	2012 04 – 2012 05	3	Anna Marciniak, Roman Hirsch Magdalena Polinska
171 Ophelia	2005 03 – 2005 04	5	Pierre Antonini
	2005 03 – 2006 07	11	Rui Goncalves
	2005 04 – 2005 04	2	Yassine Damerdji
	2005 04 – 2005 04	2	Federico Manzini
	2005 06 – 2005 06	1	Rui Goncalves, Raoul Behrend
	2006 03 – 2006 04	6	Oey (2006)
	2006 04 – 2006 04	1	Arnaud Leroy, Giller Canaud Denis Fradet, Jean-Paul Godard Raoul Behrend
	2011 04 – 2011 04	1	Jacques Montier, Denys Robilliard
	2011 04 – 2011 04	1	Jacques Montier
	2011 04 – 2011 04	5	Christophe Demeautis
180 Garumna	2004 02 – 2011 09	9	Clark (2010)
	2004 03 – 2004 03	1	Donn Starkey
	2004 03 – 2004 03	2	Stefano Sposetti, Raoul Behrend
	2004 03 – 2004 03	4	René Roy
	2007 12 – 2007 12	4	Stephens (2008)
	2011 10 – 2011 11	19	Pilcher et al. (2012a)
187 Lamberta	2004 02 – 2004 02	1	Laurent Bernasconi
	2006 10 – 2007 01	3	Hilari Pallares
	2006 11 – 2006 11	1	Enric Forné, Luis Miguel
	2006 11 – 2006 11	1	Enric Forné, Ramón Costa
	2006 11 – 2007 01	3	Enric Forné
	2011 11 – 2011 11	2	Stéphane Fauvaud, Marcel Fauvaud Franck Richard
189 Phthia	2008 07 – 2008 09	13	Pilcher (2009b)
212 Medea	2004 09 – 2013 06	7	René Roy
	2004 10 – 2004 11	4	Koff (2005)
	2004 11 – 2004 11	1	Rui Goncalves
	2004 11 – 2006 02	3	Raymond Poncy
	2010 11 – 2011 03	8	Fabien Reignier
	2010 12 – 2011 02	4	Fabien Reignier, Raoul Behrend
	2011 01 – 2011 01	8	Hiromi Hamanowa, Hiroko Hamanowa
	2014 09 – 2014 09	1	Olivier Gerteis, Paul Krafft Michel Polotto, Benoit Lesquerbault Luc Arnold, Matthieu Bachschmidt
226 Weringia	2007 08 – 2008 12	15	Oey (2008, 2009b)
	2012 09 – 2012 11	7	Pilcher (2013c)
237 Coelestina	2009 09 – 2009 09	10	Stephens (2010a)
247 Eukrate	2010 11 – 2012 05	26	Joe Garlitz
	2012 01 – 2012 05	10	Pilcher et al. (2012b)
249 Ilse	2014 11 – 2015 02	22	Pilcher (2015a)
254 Augusta	2014 10 – 2014 11	5	Pilcher (2015c)
271 Penthesilea	2009 01 – 2009 02	7	Pilcher (2009c)
274 Philagoria	2004 02 – 2004 02	2	René Roy
	2005 04 – 2005 05	4	Pierre Antonini
	2010 02 – 2010 04	6	Pilcher (2010d)
293 Brasilia	2006 04 – 2006 04	1	Stephens (2006)
	2006 04 – 2006 06	3	Oey (2006)
296 Phaetusa	2010 09 – 2010 10	5	Pilcher (2011c)
313 Chaldaea	2003 02 – 2003 03	5	Silvano Casulli
	2003 03 – 2003 04	3	Antonio Vagnozzi, Marco Cristofanelli Marco Paiella, Vairo Risoldi

Table A.2. continued.

Asteroid	Date	$N_{\rm LC}$	Observer
	2004 07 – 2004 07	4	Laurent Bernasconi
315 Constantia	2008 07 – 2008 07	3	Oey (2009a)
317 Roxane	2013 12 – 2013 12	2	Stéphane Fauvaud
	2014 02 – 2014 02	4	Stephens (2014c)
343 Ostara	2008 10 – 2008 11	11	Stephens (2009)
353 Ruperto-Carola	2006 02 – 2006 02	6	Warner (2006a)
365 Corduba	1994 12 – 2012 07	25	Stefano Mottola, Stephan Hellmich
	2006 04 – 2006 05	3	Raymond Poncy
	2007 07 – 2007 08	8	Warner (2008a)
	2012 07 – 2012 07	2	Pierre Antonini
	2012 07 – 2012 07	2	Maurice Audejean
	2012 07 – 2012 08	8	Joe Garlitz
381 Myrrha	2005 08 – 2005 08	1	Reiner Stoss, Petra Korlevic Maja Hren, Aleksandar Cikota Ljuban Jerosimic, Raoul Behrend
	2005 08 – 2005 08	3	Reiner Stoss, Jaime Nomen Salvador Sanchez, Raoul Behrend
	2010 07 – 2010 07	2	Jacques Montier, Serge Heterier
	2015 03 – 2015 03	1	Alexander Scholz, Kirstin Hay Ben Morton, Gabriella Hodosan
386 Siegena	1998 04 – 2010 04	40	Marciniak et al. (2012)
	2004 07 – 2007 03	16	Stephens (2005, 2007c)
	2011 12 – 2011 12	3	Stephan Hellmich
	2011 02 – 2011 03	7	Emmanuel Jehin, Mikael Gillon
	2012 02 – 2012 04	11	Stefano Mottola
	2012 03 – 2012 03	1	Romain Montaigut
	2012 03 – 2012 03	4	Jacques Montier
391 Ingeborg	2000 08 – 2000 12	20	Koff et al. (2001)
402 Chloe	2009 02 – 2009 02	4	Warner (2009a)
	2014 05 – 2014 05	3	Stephens (2014b)
419 Aurelia	2006 12 – 2006 12	1	René Roy
	2007 01 – 2007 01	1	Jean-François Coliac
	2008 02 – 2011 02	31	Pilcher (2008c, 2010e, 2011d)
434 Hungaria	2009 07 – 2014 03	30	Warner (2010b, 2011a, 2014b)
455 Bruchsalia	2005 11 – 2005 12	6	Koff (2006)
	2008 05 – 2008 06	9	Brinsfield (2008a)
474 Prudentia	2014 08 – 2014 08	5	Stephens (2015a)
475 Ocllo	2010 11 – 2010 12	4	Pilcher (2011b)
	2014 11 – 2014 11	4	Stephens (2015b)
482 Petrina	2007 07 – 2007 08	10	Stephens (2009)
	2010 02 – 2010 02	1	James Brinsfield
	2012 05 – 2013 10	29	Pilcher et al. (2012c), Pilcher (2014b)
489 Comacina	2001 04 – 2001 04	1	William Koff
490 Veritas	2001 02 – 2001 03	10	Koff & Brincat (2001)
497 Iva	2009 01 – 2009 01	3	Warner (2009a)
502 Sigune	2007 06 – 2014 03	19	Stephens (2007b, 2014c)
	2014 04 – 2014 04	3	Buchheim (2014)
520 Franziska	2013 12 – 2014 01	7	Pilcher (2014a)
562 Salome	2006 10 – 2006 10	4	David Higgins
	2012 11 – 2012 11	4	Alkema (2013b)
565 Marbachia	2000 03 – 2000 03	4	Koff & Brincat (2000)
	2013 08 – 2013 09	3	Stéphane Fauvaud
567 Eleutheria	2006 10 – 2006 10	2	David Higgins
	2010 04 – 2010 04	6	Ruthroff (2010)
	2010 04 – 2010 06	6	Pilcher (2010d)
	2012 11 – 2012 11	1	Maurice Audejean
	2013 11 – 2013 11	2	Stephens (2014a)
	2013 12 – 2013 12	2	Stéphane Fauvaud
586 Thekla	1999 10 – 1999 11	3	Warner (2000, 2010d)
596 Scheila	2005 12 – 2006 01	7	Warner (2006b)
625 Xenia	2010 02 – 2010 02	3	PTF, Polishook et al. (2012)
632 Pyrrha	2011 02 – 2011 03	5	Pilcher (2011d)
639 Latona	2007 09 – 2007 10	3	Warner (2008a)
644 Cosima	2012 12 – 2013 02	6	Strabla et al. (2013)
	2013 02 – 2013 02	8	Alkema (2013a)
660 Crescentia	2009 03 – 2009 03	5	Warner (2009a)
	2014 04 – 2014 05	6	Stephens et al. (2014)

Table A.2. continued.

Asteroid	Date	N_{LC}	Observer
	2014 06 – 2014 06	4	Maurice Audejean
670 Ottegebe	2014 02 – 2014 02	4	Stephens (2014c)
681 Gorgo	2013 04 – 2013 05	4	Pilcher (2013b)
682 Hagar	2013 07 – 2013 08	6	Pilcher & Franco (2014)
686 Gersuind	2013 07 – 2013 07	5	Stéphane Fauvaud
687 Tinette	1999 10 – 1999 10	3	Warner (2000, 2010d)
706 Hirundo	2000 09 – 2000 09	6	Warner (2001)
742 Edisona	2003 02 – 2003 05	7	Martin Lehký
	2008 04 – 2008 05	4	Brinsfield (2008a)
	2012 01 – 2012 02	4	Martin Lehký
746 Marlu	2014 10 – 2014 10	8	Klinglesmith et al. (2015)
749 Malzovia	2014 04 – 2014 06	5	Pilcher (2014c)
756 Lilliana	2001 07 – 2007 08	9	Warner (2010d, 2008a)
	2006 04 – 2006 04	2	Russell Durkee
	2012 04 – 2012 06	10	Pilcher (2012b)
757 Portlandia	2014 11 – 2014 11	2	Stephens (2015b)
758 Mancunia	2006 12 – 2006 12	4	Warner et al. (2008a)
	2006 12 – 2007 01	3	Raymond Poncy
	2007 01 – 2007 01	1	Jean-François Coliac, Raoul Behrend
	2007 01 – 2007 01	1	Rui Goncalves
	2007 01 – 2007 01	2	Jean-François Coliac
	2015 06 – 2015 06	2	OAdM
	2015 06 – 2015 07	7	Waldemar Ogłoza, Maciej Winiarski Marek Dróżdż
762 Pulcova	2006 02 – 2006 03	5	Oey (2006)
	2009 11 – 2009 12	3	Alton (2011)
798 Ruth	2002 08 – 2012 07	10	Stephens (2003), new
	2011 05 – 2011 05	1	Martin Lehký
802 Epyaxa	2009 01 – 2011 11	4	Warner (2009a, 2012c)
870 Manto	2013 08 – 2013 10	37	Pilcher et al. (2014)
872 Holda	2007 05 – 2007 05	8	Brinsfield (2007b)
873 Mechthild	2015 04 – 2015 06	8	Pilcher (2015b)
898 Hildegard	1999 06 – 1999 06	2	Warner (1999)
	2008 04 – 2008 05	13	David Higgins
908 Buda	2009 03 – 2009 03	5	Warner (2009a)
944 Hidalgo	2004 10 – 2004 10	4	William Koff
986 Amelia	2000 10 – 2000 10	4	Koff (2001)
1010 Marlene	2005 01 – 2005 03	8	Warner (2005b)
1021 Flammario	2005 01 – 2005 01	2	Buchheim (2005)
1023 Thomana	2009 09 – 2009 10	8	Brinsfield (2010b)
1080 Orchis	2010 10 – 2010 10	5	Strabla et al. (2011)
	2010 10 – 2010 11	8	Ruthroff (2011)
1103 Sequoia	2011 08 – 2014 11	11	Warner (2011b, 2015a,c)
1110 Jaroslawa	2013 02 – 2013 04	20	Julian Oey
	2014 08 – 2014 11	24	Pilcher et al. (2015)
1125 China	2013 10 – 2013 10	2	Stephens (2014a)
1137 Raissa	2012 09 – 2012 12	31	Ferrero et al. (2014)
1175 Margo	2009 06 – 2009 07	4	Brinsfield (2010a)
1244 Deira	2007 02 – 2007 04	21	Julian Oey
1278 Kenya	2011 04 – 2011 06	27	Oey et al. (2012)
1310 Villigera	2001 09 – 2001 10	4	Koff (2002)
1312 Vassar	2010 11 – 2010 11	1	Julian Oey
	2010 11 – 2010 11	3	David Higgins
1352 Wawel	2007 12 – 2007 12	5	Brinsfield (2008b)
1360 Tarka	2004 09 – 2014 02	10	Warner (2005a, 2014b)
1366 Piccolo	2003 04 – 2005 12	7	René Roy, Raoul Behrend
1424 Sundmania	2012 03 – 2012 04	14	Stephens (2012)
1430 Somalia	2011 09 – 2011 09	6	Strabla et al. (2012)
1449 Virtanen	2008 05 – 2008 07	11	Oey (2009b)
1486 Marilyn	2013 08 – 2013 08	5	Benishek (2014)
1508 Kemi	2004 02 – 2004 03	3	Koff (2004)
1546 Izsak	2006 04 – 2006 04	3	Warner (2006c)
1672 Gezelle	2008 10 – 2008 11	9	Brinsfield (2009)
	2008 11 – 2008 11	2	Brian Warner
1676 Kariba	2009 03 – 2009 03	3	David Higgins
1730 Marceline	2010 09 – 2010 09	2	Brinsfield (2011)
1750 Eckert	2009 09 – 2009 11	23	Warner (2010c)

Table A.2. continued.

Asteroid		Date	N_{LC}	Observer
1789	Dobrovolsky	2011 03 – 2011 03	2	Brian Skiff
1793	Zoya	2008 05 – 2008 05	4	Brinsfield (2008a)
1820	Lohmann	2011 08 – 2011 10	8	David Higgins
		2011 09 – 2011 10	8	Martinez (2012)
1825	Klare	2003 12 – 2004 01	5	Pray (2004a)
1925	Franklin-Adams	2013 01 – 2013 01	2	Warner (2013b)
2001	Einstein	2004 12 – 2012 12	13	Warner (2005b, 2008b, 2010c, 2013a)
2306	Bauschinger	2011 08 – 2011 08	6	Warner (2012b)
2358	Bahner	2008 09 – 2008 10	13	Owings (2009)
2381	Landi	2014 01 – 2014 02	4	Klinglesmith et al. (2014)
		2014 02 – 2014 02	2	Stephens (2014c)
2382	Nonie	2005 08 – 2005 08	6	Warner (2006d)
2495	Noviomagum	2013 07 – 2013 07	4	Warner (2014a)
2725	David	2006 02 – 2006 02	3	Warner (2006a)
2741	Valdivia	2003 05 – 2003 06	4	Pray (2004b)
3258	Somnium	2006 10 – 2006 10	7	Oey et al. (2007)
3266	Bernardus	2009 03 – 2014 01	15	Warner (2009c, 2011a, 2012d, 2014b)
3285	Ruth Wolfe	1999 11 – 1999 11	3	Warner (2011c)
3301	Jansje	2012 06 – 2012 07	8	Owings (2013b)
3478	Fanale	2012 10 – 2012 10	2	Stephens (2013)
		2012 10 – 2012 10	3	Owings (2013a)
3544	Borodino	2007 10 – 2007 10	2	David Higgins
		2014 06 – 2014 07	5	Cantu et al. (2015)
3752	Camillo	1995 08 – 1995 08	9	Pravec et al. (1998)
3773	Smithsonian	2006 09 – 2006 09	5	Stephens (2007a)
3786	Yamada	2002 07 – 2002 08	3	Stephens (2003)
3918	Brel	2005 11 – 2005 11	1	David Higgins
4265	Kani	2008 10 – 2008 10	4	Miles & Warner (2009)
4490	Bambery	2006 02 – 2014 01	15	Warner (2006a, 2009c, 2011a, 2012d, 2014b)
4570	Runcorn	2007 03 – 2007 05	11	Julian Oey
4764	Joneberhart	2007 01 – 2010 03	5	Warner (2007a, 2010a)
		2013 05 – 2013 05	3	Stephens et al. (2014)
5332	Davidaguilar	2006 01 – 2006 01	1	Julian Oey
		2008 09 – 2009 02	3	Skiff et al. (2012)
5489	Oberkochen	2013 12 – 2013 12	3	Stephens (2014a)
6087	Lupo	2010 07 – 2012 02	7	Warner (2011b, 2012a)
6192	1990 KB1	2010 02 – 2010 02	2	PTF, Polishook et al. (2012)
		2011 06 – 2011 07	14	Brinsfield (2012)
6406	1992 MJ	2006 06 – 2006 06	3	Higgins & Goncalves (2007)
6410	Fujiwara	2005 07 – 2005 08	2	David Higgins
6517	Buzzi	2004 07 – 2014 02	17	Warner (2005c, 2009a, 2012d, 2014b)
7660	1993 VM1	2011 07 – 2014 08	8	Warner (2012b, 2015a)
8567	1996 HW1	2005 06 – 2005 07	6	Higgins et al. (2006b)
		2008 08 – 2009 01	39	Magri et al. (2011)
11058	1991 PN10	2010 07 – 2012 02	7	Warner (2011b, 2012a)
14197	-	2010 02 – 2010 02	4	PTF, Polishook et al. (2012)
16468	-	2010 02 – 2010 02	1	PTF, Polishook et al. (2012)
28736	2000 GE133	2007 05 – 2007 05	3	Higgins (2008)
28887	2000 KQ58	2005 11 – 2005 12	6	Higgins et al. (2006c)
33116	1998 BO12	2006 05 – 2006 05	4	Higgins et al. (2006a)
67404	-	2011 08 – 2014 10	7	Warner (2012b, 2015a)
86257	1999 WK13	2010 12 – 2012 07	13	Warner (2015b)

Table A.3. Observers, observatory code and observatory name.

Observer name	Obs code	Observatory name
Olivier Adam	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Veronika Afonina	482	Observatory of the University of St Andrews, United-Kingdom
Rémi Anquetin	586	Pic du Midi Observatory
Pierre Antonini	132	Observatoire des Hauts Patys, F-84410 Bédoin, France
Luc Arnold	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Maurice Audejean	B92	Observatoire de Chinon, Mairie de Chinon, 37500 Chinon, France
Pierre Aurard	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Matthieu Bachschmidt	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Bryan Baduel	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Eric Barbotin		Villefagnan Observatory, France
Pierre Barroy	586	Pic du Midi Observatory
Philippe Baudouin		Harfleur Observatory, France
Lucas Berard	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Nathanael Berger		490 chemin du gonnet, F-38440 Saint Jean de Bournay, France
Laurent Bernasconi	A14	Observatoire des Engarouines, 1606 chemin de Rigoy, F-84570 Malemort-du-Comtat, France
Jean-Gabriel Bosch	178	Collonges Observatory, 90 allée des résidences, F-74160 Collonges, France
Sylvain Bouley	586	Pic du Midi Observatory
Inna Bozhinova	482	Observatory of the University of St Andrews, United-Kingdom
James Brinsfield	G69	Via Capote Observatory, Thousand Oaks, CA 91320, USA
Laurent Brunetto	139	Le Florian, Villa 4, 880 chemin de Ribac-Estagnol, F-06600 Antibes, France
Giller Canaud	586	Pic du Midi Observatory
Jérôme Caron	A77	Observatoire de Dauban, F-04150 Banon, France
Jérôme Caron	C26	Levendaal Observatory, Uiterstegracht 48, 2312 TE Leiden, Netherlands
Fabien Carrier	809	European Southern Observatory, La Silla, Coquimbo, Chile
Giovanni Casalnuovo	C62	Eurac Observatory, Bolzano, Italy
Silvano Casulli	A55	Vallemare di Bordona, Rieti, Italy
Mateu Cerda	B81	Observatorio Astronómico Caimari
Loïc Chalamet	F59	Ironwood North, Hawaii, USA
Stéphane Charbonnel	949	Observatoire de Durtal, F-49430 Durtal, France
Chinaglia	C62	Eurac Observatory, Bolzano, Italy
Aleksandar Cikota	620	OAM - Mallorca
François Colas	586	Pic du Midi Observatory
Jean-François Coliac		20 parc des Pervenches, F-13012 Marseille, France
Arnaud Collet	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Josep Coloma	619	Agrupación Astronómica de Sabadell, Apartado de Correos 50, PO Box 50, 08200 Sabadell, Barcelona, Spain
Josep Coloma	B71	Observatorio El Vendrell
Matthieu Conjat	020	Observatoire de Nice, France
Emmanuel Conseil		AFOEV (Association Française des Observateurs d'Etoiles Variables), Observatoire de Strasbourg 11, rue de l'Université, 67000 Strasbourg, France
Corentin	C62	Eurac Observatory, Bolzano, Italy
Ramón Costa	619	Agrupación Astronómica de Sabadell, Apartado de Correos 50, PO Box 50, 08200 Sabadell, Barcelona, Spain
Ramón Costa	B22	Observatorio d'Ager, Barcelona, Spain
Roberto Crippa	A12	Stazione Astronomica di Sozzago, I-28060 Sozzago, Italy
Marco Cristofanelli	589	Santa Lucia Stroncone, Italy
Yassine Damerdji	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Andre Debackère	F59	Ironwood North, Hawaii, USA
Alice Decock	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Quentin Déhais		Seine-Maritime, Le Havre, Haute-Normandie 76600, France
Tanguy Déléage	F65	Haleakala-Faulkes Telescope North, Hawaii, US
Sophie Delmelle	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Christophe Demeautis	138	Village-Neuf Observatory, 9bis rue du Sauvage, F-68300 Saint-Louis, France
Marek Dróżdż		Mt. Suhora Observatory, Pedagogical University. Podchorążych 2, 30-084, Cracow, Poland
Guillaume Dubos	586	Pic du Midi Observatory
Thomas Dulcamara	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Maïte Dumont	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Russell Durkee	H39	Shed of Science Observatory, 5213 Washburn Ave. S, Minneapolis, MN 55410, USA
Roger Dymock	940	Waterlooville
Nicolas Esseiva	K27	Observatoire St-Martin, 31 grande rue, F-25330 Amathay Vésigneux, France
Robin Esseiva	K27	Observatoire St-Martin, 31 grande rue, F-25330 Amathay Vésigneux, France
Mateu Esteban	B81	Observatorio Astronómico Caimari
Mateu Esteban	C33	Observatorio CEAM, Caimari, Canary Islands, Spain
Thomas Fauchez	511	Haute-Provence Observatory, St-Michel l'Observatoire, France

Notes. TRAPPIST – TRAnsiting Planets and Planetesimal Small Telescope, Jehin et al. (2011).

Table A.3. continued.

Observer name	Obs code	Observatory name
Michael Fauerbach	H72	Florida Gulf Coast University, 10501 FGCU Boulevard South, Fort Myers, FL 33965, USA
Marcel Fauvaud		Observatoire du Bois de Bardon, F-16110 Taponnat, France
Stéphane Fauvaud		Observatoire du Bois de Bardon, F-16110 Taponnat, France
Stéphane Fauvaud	586	Pic du Midi Observatory
Florian	517	Geneva Observatory, 1290 Sauverny, Switzerland
Enric Forné	619	Agrupación Astronómica de Sabadell, Apartado de Correos 50, PO Box 50, 08200 Sabadell, Barcelona, Spain
Enric Forné	B29	Osservatorio l'Ampolla, Tarragona, Spain
Carine Fournel	F59	Ironwood North, Hawaii, USA
Denis Fradet	586	Pic du Midi Observatory
Joe Garlitz		International Occultation Timing Association, Montgomery, AL, USA
Olivier Gerteis	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Christophe Gillier	634	Club d'Astronomie de Lyon Ampere (CALA), Place de la Nation, 69120 Vaulx-en-Velin, France
Mikael Gillon	I40	TRAPPIST, ESO la Silla Observatory, Chile
René Giraud	I40	TRAPPIST, ESO la Silla Observatory, Chile
Jean-Paul Godard	586	Pic du Midi Observatory
Rui Goncalves	938	Linhaceira Observatory, Portugal
Hiroko Hamanowa	D19	Hong Kong Space Museum, Tsimshatsui, Hong Kong, China
Hiromi Hamanowa	D19	Hong Kong Space Museum, Tsimshatsui, Hong Kong, China
Josef Hanuš	557	Ondřejov Observatory, Czech Republic
Kirstin Hay	482	Observatory of the University of St Andrews, United-Kingdom
Stephan Hellmich	493	Calar Alto Observatory
Serge Heterier	615	St. Véran
Serge Heterier	J23	Centre astronomique de la Couyère, 30 rue de la Boulais, F-35000 Rennes, France
David Higgins	E14	Hunters Hill Observatory, 7 Mawalan Street, Ngunnawal ACT 2913, Australia
Roman Hirsch	187	Borowiec station of Astronomical Observatory Institute UAM, Poznań, Poland
Gabriella Hodosan	482	Observatory of the University of St Andrews, United-Kingdom
Maja Hren	620	OAM - Mallorca
Alex Hygate	482	Observatory of the University of St Andrews, United-Kingdom
Niyonzima Innocent	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Herve Jacquinot	B26	Observatoire des Terres Blanches, Reillanne
Sharat Jawahar	482	Observatory of the University of St Andrews, United-Kingdom
Emmanuel Jehin	I40	TRAPPIST, ESO la Silla Observatory, Chile
Ljuban Jerosimic	620	OAM - Mallorca
Alain Klotz	148	Guitalens Observatory, 5 chemin d'En Combes, F-81220 Guitalens, France
Alain Klotz	181	Observatoire Les Makes, G. Bizet 18, F-97421 La Rivière, France
Alain Klotz	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
William Koff	H09	980 Antelope Drive West, Bennett, CO 80102, USA
Petra Korlevic	620	OAM - Mallorca
Ewa Kosturkiewicz		Mt. Suhora Observatory, Pedagogical University. Podchorążych 2, 30-084, Cracow, Poland
Paul Krafft	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Yurij Krugly	121	Institute of Astronomy of Kharkiv National University, Kharkiv, Ukraine
François Kugel	A77	Observatoire de Dauban, F-04150 Banon, France
Olivier Labrevoir	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Jean Lecacheux	586	Pic du Midi Observatory
Martin Lehký		Severní 765, 50003, Hradec Králové, Czech republic
Arnaud Leroy	586	Pic du Midi Observatory
Arnaud Leroy	A07	Uranoscope, Avenue Carnot 7, F-77220 Gretz-Armainvilliers, France
Arnaud Leroy	Z97	Observatoire OPERA, France
Benoit Lesquerbault	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
M. J. López-Gonzáles		Instituto de Astrofísica de Andalucía, CSIC, Apdo. 9481, 08080 Barcelona, Spain
Marine Lutz	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Bruno Mallecot	586	Pic du Midi Observatory
Jean Manfroid	I40	TRAPPIST, ESO la Silla Observatory, Chile
Federico Manzini	A12	Stazione Astronomica di Sozzago, I-28060 Sozzago, Italy
Anna Marciniak	187	Borowiec station of Astronomical Observatory Institute UAM, Poznań, Poland
Axel Martin	628	Mulheim-Ruhr, Germany
Axel Martin	H10	Tzec Maun Foundation Observatory, Mayhill, New Mexico, US
Benjamin Modave	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Romain Montaigut	586	Pic du Midi Observatory
Romain Montaigut	634	Club d'Astronomie de Lyon Ampere (CALA), Place de la Nation, 69120 Vaulx-en-Velin, France
Romain Montaigut	Z97	Observatoire OPERA, France
Jacques Montier	615	Astroqueyras, Mairie, F-05350 Saint-Véran, France
Jacques Montier	J23	51 Centre astronomique de la Couyère, La Ville d'ABas, F-35320 La Couyère, France
Etienne Morelle		20 parc des Pervenches, F-13012 Marseille, France
Ben Morton	482	Observatory of the University of St Andrews, United-Kingdom
Stefano Mottola		Institute of Planetary Research, German Aerospace Center, Rutherfordstrasse 2,

Table A.3. continued.

Observer name	Obs code	Observatory name
		12489, Berlin, Germany
Ramon Naves	213	Observatorio Montcabrer, C/Jaume Balmes nb 24, Cabrils 08348, Barcelona, Spain
Jaime Nomen	620	OAM - Mallorca
Julian Oey	E19	Kingsgrove, NSW, Australia
Waldemar Ogłoza		Mt. Suhora Observatory, Pedagogical University. Podchorążych 2, 30-084, Cracow, Poland
Marco Paiella	589	Santa Lucia Stroncone, Italy
Hilari Pallares	619	Agrupación Astronómica de Sabadell, Apartado de Correos 50, PO Box 50, 08200 Sabadell, Barcelona, Spain
Hilari Pallares	A90	Sant Gervasi Observatory, Barcelona
Andre Peyrot	181	Observatoire Les Makes, G. Bizet 18, F-97421 La Rivière, France
Frederick Pilcher	G50	4438 Organ Mesa Loop, Las Cruces, NM 88011, USA
Jean-François Pirenne	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Pierre Piron	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Magdalena Polinska	187	Borowiec station of Astronomical Observatory Institute UAM, Poznań, Poland
Michel Polotto	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Raymond Poncy	177	Rue des Ecoles 2, F-34920 Le Crès, France
Jean Pierre Previt	J23	Centre astronomique de la Couyère, 30 rue de la Boulais, F-35000 Rennes, France
Fabien Reignier		11 rue François-Nouteau, F-49650 Brain-sur-Allonnes, France
Damien Renauld	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Davide Ricci	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Franck Richard	586	Pic du Midi Observatory
Claudine Rinner	224	Ottmarsheim Observatory, 5 rue du Lièvre, F-68490 Ottmarsheim, France
Vairo Risoldi	589	Santa Lucia Stroncone, Italy
Denys Robilliard	J23	Centre astronomique de la Couyère, 30 rue de la Boulais, F-35000 Rennes, France
David Romeuf		Université Claude BERNARD Lyon 1, Observatoire de Pommier, POMMIER, F-63230 Chapdes-Beaufort, France
Gérald Rousseau		4 rue de la Bruyère, F-37500 La Roche Clermault, France
René Roy	627	Observatoire de Blauvac, 293 chemin de St Guillaume, F-84570 Blauvac, France
John Ruthroff		Shadowbox Observatory, 12745 Crescent Drive, Carmel, IN 46032, USA
Pére Antoni Salom	B81	Observatorio Astronómico Caimari
Pére Antoni Salom	C33	Observatorio CEAM, Caimari, Canary Islands, Spain
Toni Santana-Ros	187	Borowiec station of Astronomical Observatory Institute UAM, Poznań, Poland
Lucas Salvador	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Salvador Sanchez	620	OAM – Mallorca
Alexander Scholz	482	Observatory of the University of St Andrews, United-Kingdom
Gwendoline Séné	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Brian Skiff	690	Lowell Observatory, Flagstaff, AZ 86001, USA
Krzysztof Sobkowiak	187	Borowiec station of Astronomical Observatory Institute UAM, Poznań, Poland
Patrick Sogorb	B00	Savigny-le-Temple
Francisco Soldán	Z74	Observatorio Amanecer de Arrakis, Alcalá de Guadaíra, Sevilla, Spain
Axelle Spiridakis	F65	Haleakala-Faulkes Telescope North, Hawaii, US
Emilia Splanska	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Stefano Sposetti	143	Gnosca Observatory, CH-6525 Gnosca, Switzerland
Donn Starkey	H63	DeKalb Observatory, 2507 CR 60, Auburn, IN 46706, USA
Robert Stephens	646	Center for Solar System Studies, 9302 Pittsburgh Ave, Suite 105, Rancho Cucamonga, CA 91730, USA
Arnaud Stiepen	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Reiner Stoss	620	OAM – Mallorca
Jean Strajnic	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Jean-Paul Teng	181	Observatoire Les Makes, G. Bizet 18, F-97421 La Rivière, France
Titouan	C62	Eurac Observatory, Bolzano, Italy
Greg Tumolo	482	Observatory of the University of St Andrews, United-Kingdom
Antonio Vagnozzi	589	Santa Lucia Stroncone, Italy
Benjamin Vanoutryve	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Jean Marie Vugnon		Association T60, 14 avenue Edouard Belin, F-31400 Toulouse, France
Brian Warner	716	Palmer Divide Observatory, 17995 Bakers Farm Rd., Colorado Springs, CO 80908, USA
Jean Marie Vugnon	586	Pic du Midi Observatory
Brian Warner	U82	Center for Solar System Studies/MoreData!, 446 Sycamore Ave., Eaton, CO 80615, USA
Mathieu Waucomont	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Olivier Wertz	511	Haute-Provence Observatory, St-Michel l'Observatoire, France
Maciej Winiarski		Mt. Suhora Observatory, Pedagogical University. Podchorążych 2, 30-084, Cracow, Poland
Marek Wolf	557	Ondřejov Observatory, Czech Republic
OAdM	C65	Joan Oró Telescope (TJO) of the Montsec Astronomical Observatory (OAdM)