

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2022 OCTOBER-DECEMBER

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We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling using lightcurve inversion. The “Radar-Optical Opportunities” section includes a list of potential radar targets as well as some that might be in critical need of astrometric data.

We present several lists of asteroids that are prime targets for photometry and/or astrometry during the period 2022 October through December. The “Radar-Optical Opportunities” section provides an expanded list of potential NEA targets, many of which are planned or good candidates for radar observations.

In the first three sets of tables, “Dec” is the declination and “U” is the quality code of the lightcurve. See the latest asteroid lightcurve data base (LCDB from here on; Warner et al., 2009) documentation for an explanation of the U code:

<http://www.minorplanet.info/lightcurvedatabase.html>

The ephemeris generator on the MinorPlanet.info web site allows creating custom lists for objects reaching $V \leq 18.0$ during any month in the current year and up to five years in the future, e.g., limiting the results by magnitude and declination, family, and more.

<https://www.minorplanet.info/php/callopplcdbquery.php>

We refer you to past articles, e.g., Warner et al. (2021a; 2021b) for more detailed discussions about the individual lists and points of advice regarding observations for objects in each list.

Once you’ve obtained and analyzed your data, it’s important to publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It’s also important to make the data available at least on a personal website or upon request. We urge you to consider submitting your raw data to the ALCDEF database. This can be accessed for uploading and downloading data at

<http://www.alcdef.org>

The database contains more than 10.1 million observations for 23993 objects (as of 2022 July 2), making it one of the more useful sources for raw data of *dense* time-series asteroid photometry.

Lightcurve/Photometry Opportunities

Objects with U = 3- or 3 are excluded from this list since they will likely appear in the list for shape and spin axis modeling. Those asteroids rated U = 1 or have only a lower limit on the period, should be given higher priority over those rated U = 2 or 2+. On the other hand, do not overlook asteroids with U = 2/2+ on the assumption that the period is sufficiently established. Regardless, do not let the existing period influence your analysis since even highly-rated result have been proven wrong at times. Note that the lightcurve amplitude in the tables could be more or less than what’s given. Use the listing only as a guide.

Number	Name	Brightest			LCDB Data		U
		Date	Mag	Dec	Period	Amp	
2974	Holden	10 01.4	15.1	+9	856	0.70	2+
5887	Yauza	10 05.1	15.0	+4	54.78	0.30	2
5811	Keck	10 08.4	14.9	+17	>30	0.25	2
1599	Giomus	10 09.6	14.7	+2	9.53	0.06-0.08	2
7194	Susanrose	10 11.5	15.0	+3	4.725	0.24	2
5479	Grahamryder	10 11.7	15.4	+8	7.6	0.08-0.30	2
1438	Wendeline	10 14.9	14.5	+10	41.98	0.23	2-
15790	Keizan	10 17.0	14.8	+9	19.68	0.25	2-
3925	Tret'yakov	10 17.4	14.6	-6	30.962	0.24	2+
2908	Shimoyama	10 19.5	15.3	+19	694.117	0.41	2
1399	Teneriffa	10 21.8	15.1	+1	2.692	0.14	2
35143	1992 UF1	10 22.5	15.5	+10	5.388	0.23-0.26	2
2052	Tamriko	10 22.7	14.3	+12	7.462	0.06-0.15	2
1573	Vaisala	10 26.6	13.9	+2	252	0.76	2
8830	1988 VZ	10 28.4	15.4	+12	7.16		2
21609	Williamcaleb	10 28.8	15.3	+8	112	0.5	2
2757	Crisser	10 30.3	15.1	+14	8.088	0.28	2
3373	Koktebelia	11 02.0	15.2	+10	405.33	0.67	2
9216	Masuzawa	11 02.1	15.3	+15	5.02	0.15	2
7004	Markthiemens	11 03.4	15.5	+14	6.025		2-
18595	1998 BR1	11 07.0	15.0	+16	6.02		2
37306	2001 KW46	11 07.1	14.8	+22	5.621	0.10	2
1690	Mayrhofer	11 10.0	14.7	+18	22.194	0.16-0.45	2
1965	van de Kamp	11 10.1	14.7	+15	>36	0.5	1
5163	Vollmayr-Lee	11 10.8	14.8	+7	4.728	0.15	2
23978	1999 JF21	11 10.8	15.0	+17	34.15	0.09	2
1500	Jyvaskyla	11 13.2	14.0	+26	8.828		2
4649	Sumoto	11 14.2	14.7	+5	26.31	0.15-0.30	2
217628	Lugh	11 14.9	14.7	-7	8.55	0.08	1
2774	Tenojoki	11 15.5	15.3	+29	11.2	0.30	2+
85713	1998 SS49	11 16.3	13.9	+45	5.37	0.06-0.18	2
3153	Lincoln	11 17.6	15.2	+23	4.819	0.08	2
2107	Ilmari	11 18.4	14.6	+16	39.916	0.21	2-
27057	1998 SP33	11 21.6	15.0	+31	7.03	0.23	2+
4943	Lac d'Orient	11 21.9	15.5	+21	11.81	0.42-0.56	2
3454	Lieske	11 22.1	15.1	+12	105	0.73	2-
10260	1972 TC	11 22.2	15.3	+23	3.716	0.54	2
2439	Ulugbek	11 28.8	15.3	+21	4.26		2-
1384	Kniertje	11 29.9	14.5	+1	9.807	0.11-0.33	2
1549	Mikko	12 01.8	14.3	+19	8.74	0.10	2
4817	Gliba	12 02.7	15.1	+17	23.66	0.3	2-
66875	1999 VY52	12 02.9	14.6	+24	2.148	0.25	2
19311	1996 VF3	12 06.2	15.4	+32	13.883	0.35	2
1565	Lemaitre	12 06.4	13.7	+29	11.403	0.03-0.04	2
16872	1998 BZ	12 09.9	15.5	+20	2.81	0.34-0.45	2
11151	Oodaigahara	12 10.8	15.1	+27	15.35	0.20	2
645	Agrippina	12 15.2	13.8	+34	32.6	0.11-0.18	2
3981	Stodola	12 18.1	15.4	+24	102.657	0.08	1
2014	HK129	12 18.8	14.7	-23	>10	0.5	2
2707	Ueferji	12 25.1	15.5	+24	5.286	0.16	2
6901	Roybishop	12 25.7	15.0	+35	4.766	0.04-0.09	2
1239	Queteleta	12 25.9	14.3	+25	10.278	0.03	1
28017	1997 YV13	12 27.9	14.8	+21	47	0.15	1

Low Phase Angle Opportunities

The Low Phase Angle list includes asteroids that reach very low phase angles ($\alpha < 1^\circ$). The “ α ” column is the minimum solar phase angle for the asteroid. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the “opposition effect.”

Use the on-line query form for the LCDB to get more details about a specific asteroid.

<https://www.minorplanet.info/php/callopplcdbquery.php>

The best chance of success comes with covering at least half a cycle a night, meaning periods generally < 16 h, when working objects with low amplitude. Objects with large amplitudes and/or long periods are much more difficult for phase angle studies since, for proper analysis, the data must be reduced to the average magnitude of the asteroid for each night. Refer to Harris et al. (1989) for the details of the analysis procedure.

As an aside, it is arguably better for physical interpretation (e.g., G value versus albedo) to use the maximum light rather than mean level to find the phase slope parameter (G), which better models the behavior of a spherical object of the same albedo, but it can produce significantly different values for both H and G versus using average light, which is the method used for values listed by the Minor Planet Center. Using and reporting the results of both methods can provide additional insights into the physical properties of an asteroid.

The International Astronomical Union (IAU) has adopted a new system, $H-G_{12}$, introduced by Muinonen et al. (2010). It will be some years before $H-G_{12}$ becomes widely used, and hopefully not until a discontinuity flaw in the G_{12} function has been fixed. This discontinuity results in false “clusters” or “holes” in the solution density and makes it impossible to draw accurate conclusions.

We strongly encourage obtaining data as close to 0° as possible, then every $1-2^\circ$ out to 7° , below which the curve tends to be non-linear due to the opposition effect. From 7° out to about 30° , observations at $3-6^\circ$ intervals should be sufficient. Coverage beyond 50° or so is not generally helpful since the $H-G$ system is best defined with data from $0-30^\circ$.

It's important to emphasize that all observations should (must) be made using high-quality catalogs to set the comparison star magnitudes. These include ATLAS, Pan-STARRS, SkyMapper, and Gaia2/3. Catalogs such as CMC-15, APASS, or the MPOSC from *MPO Canopus* have too high of significant systematic errors.

Also important is that there are sufficient data from each observing run such that their location can be found on a combined, phased lightcurve derived from two or more nights obtained *near the same phase angle*. If necessary, the magnitudes for a given run should be adjusted so that they correspond to mid-light of the combined lightcurve. This goes back to the $H-G$ system being based on average, not maximum or minimum light.

The asteroid magnitudes are brighter than in others lists because higher precision is required and the asteroid may be a full magnitude or fainter when it reaches phase angles out to $20-30^\circ$.

Num	Name	Date	α	V	Dec	Period	Amp	U
277	Elvira	10 02.5	0.50	13.1	+05	29.69	0.34-0.59	3
1527	Malmquista	10 04.4	0.56	13.3	+03	14.077	0.42-0.54	3
231	Vindobona	10 07.3	0.98	13.7	+08	14.245	0.20-0.29	3
108	Hecuba	10 17.6	0.97	12.8	+12	14.256	0.09-0.12	3
2243	Lonnrot	10 23.9	0.93	14.0	+13			
83	Beatrice	10 29.3	0.43	12.0	+14	10.16	0.18	3
658	Asteria	10 30.3	0.64	13.9	+15	21.034	0.22-0.28	3
124	Alkeste	11 09.0	1.00	11.8	+14	9.906	0.08-0.30	3
384	Burdigala	11 16.0	0.42	12.0	+20	21.1	0.03	2-
419	Aurelia	11 16.8	0.19	12.6	+18	16.784	0.07-0.27	3
478	Tergeste	11 16.8	0.12	11.7	+19	16.101	0.14-0.29	3-
1264	Letaba	11 18.0	0.07	14.0	+19	32.74	0.11-0.28	3
264	Libussa	11 19.4	0.91	11.2	+22	9.2276	0.04-0.59	3
673	Edda	11 25.3	0.45	13.6	+20	22.340	0.12-0.21	3

Num	Name	Date	α	V	Dec	Period	Amp	U
208	Lacrimosa	11 26.0	0.78	13.0	+23	14.085	0.15-0.33	3
686	Gersuind	11 27.8	0.43	12.4	+20	6.3127	0.33-0.37	3
229	Adelinda	12 06.4	0.61	13.9	+25	6.60	0.04-0.30	3
316	Goberta	12 07.9	0.96	13.7	+20	8.605	0.20-0.27	3
121	Hermione	12 20.0	0.83	11.9	+26	5.5513	0.04-0.62	3
259	Aletheia	12 20.0	0.07	12.6	+24	8.143	0.12	3

Shape/Spin Modeling Opportunities

Those doing work for modeling should contact Josef Ďurech at the email address above. If looking to add lightcurves for objects with existing models, visit the Database of Asteroid Models from Inversion Techniques (DAMIT) web site

<https://astro.troja.mff.cuni.cz/projects/damit/>

Additional lightcurves could lead to the asteroid being added to or improving one in DAMIT, thus increasing the total number of asteroids with spin axis and shape models.

Included in the list below are objects that:

1. Are rated U = 3- or 3 in the LCDB.
2. Do not have reported pole in the LCDB Summary table.
3. Have at least three entries in the Details table of the LCDB where the lightcurve is rated U ≥ 2 .

The caveat for condition #3 is that no check was made to see if the lightcurves are from the same apparition or if the phase angle bisector longitudes differ significantly from the upcoming apparition. The last check is often not possible because the LCDB does not list the approximate date of observations for all details records. Including that information is an on-going project.

Favorable apparitions are in bold text. NEAs are in italics.

Num	Name	Brightest			LCDB Data		
		Date	Mag	Dec	Period	Amp	U
1829	Dawson	10 01.1	14.8	+13	4.254	0.05-0.32	3
479	Caprera	10 03.9	12.4	-8	9.454	0.05-0.25	3
2151	Hadwiger	10 07.6	14.4	-1	5.872	0.07-0.38	3
1184	Gaea	10 08.0	14.5	+12	2.871	0.09-0.15	3-
696	Leonora	10 08.2	13.0	+24	26.896	0.04-0.31	3
397	Vienna	10 08.6	11.5	+19	15.48	0.15-0.20	3
2105	Gudy	10 08.9	14.7	+46	15.795	0.18-0.52	3-
488	Kreusa	10 10.2	13.2	-7	32.645	0.08-0.20	3
1756	Giacobini	10 10.3	14.0	+16	3.853	0.21-0.29	3
965	Angelica	10 11.9	14.1	-9	26.752	0.06-0.12	3-
466	Tisiphone	10 12.9	14.0	+31	8.834	0.03-0.18	3
738	Alagasta	10 13.2	14.5	+3	17.89	0.11-0.20	3-
850	Altona	10 24.4	14.6	-9	11.191	0.09-0.17	3
790	Pretoria	10 27.0	13.2	+30	10.37	0.05-0.18	3
1603	Neva	10 27.2	14.3	+0	6.426	0.16-0.25	3-
658	Asteria	10 30.3	13.9	+15	21.034	0.22-0.28	3
2150	Nyctimene	10 30.6	14.9	-2	6.131	0.56-0.90	3
6244	Okamoto	10 31.6	15.0	+25	2.896	0.11-0.15	3
1100	Arnica	11 02.3	14.7	+16	14.535	0.09-0.28	3
2227	Otto Struve	11 02.7	15.0	+8	5.397	0.15-0.19	3
619	Triberga	11 04.2	12.9	+3	29.311	0.25-0.45	3
101	Helena	11 07.5	11.5	+31	23.08	0.09-0.13	3
4363	Sergej	11 10.3	15.0	+7	13.04	0.24-0.50	3-
777	Gutemberga	11 13.9	14.9	+32	12.838	0.11-0.28	3
839	Valborg	11 14.3	14.4	+38	10.366	0.14-0.19	3
1304	Arosa	11 14.7	14.5	+3	7.748	0.13-0.38	3
929	Algunde	11 15.9	14.6	+18	3.31	0.11-0.17	3
653	Berenike	11 17.2	13.9	+3	12.489	0.03-0.11	3
1143	Odysseus	11 17.2	14.8	+18	10.114	0.15-0.22	3
1264	Letaba	11 18.0	14.0	+19	32.74	0.13-0.43	3
58	Concordia	11 18.5	12.8	+12	9.895	0.01-0.15	3
1132	Hollandia	11 18.7	15.0	+24	5.322	0.15-0.35	3
954	Li	11 21.8	14.5	+18	7.207	0.11-0.25	3
388	Charybdis	11 24.4	12.9	+29	9.516	0.14-0.25	3
57	Mnemosyne	11 27.5	11.1	+4	25.324	0.09-0.24	3-
2034	Bernoulli	11 30.5	14.2	+35	6.249	0.19-0.27	3
1052	Belgica	12 01.4	13.6	+17	2.71	0.06-0.08	3
1031	Arctica	12 05.1	14.0	+8	24.904	0.16-0.22	3

Num	Name	Brightest			LCDB Data			U
		Date	Mag	Dec	Period	Amp		
917	Lyka	12 06.4	14.5	+32	7.867	0.10-0.26	3	
806	Gyldenien	12 10.3	14.8	+35	16.852	0.10-0.27	3	
911	Agamemnon	12 10.6	14.8	+49	6.592	0.04-0.29	3	
1660	Wood	12 13.9	13.7	-10	6.809	0.14-0.26	3	
1509	Esclangona	12 14.2	14.5	+42	3.253	0.11-0.35	3	
1589	Fanatica	12 16.7	14.5	+22	2.583	0.10-0.22	3	
788	Hohensteina	12 17.0	13.8	+3	37.137	0.10-0.18	3	
1046	Edwin	12 18.1	14.7	+35	5.291	0.14-0.27	3	
2494	Inge	12 18.2	15.0	+28	6.79	0.17-0.92	3	
1274	Delportia	12 18.3	14.8	+30	5.56	0.05-0.29	3	
259	Aletheia	12 20.0	12.7	+24	8.143	0.09-0.12	3	
1967	Menzel	12 24.1	13.9	+28	2.835	0.16-0.39	3	
100	Hekate	12 26.4	12.5	+18	27.066	0.11-0.23	3	
224	Oceana	12 26.8	12.5	+32	9.401	0.09-0.14	3	
1116	Catriona	12 27.4	13.0	+51	8.832	0.09-0.28	3	

Radar-Optical Opportunities

Table I below gives a list of near-Earth asteroids reaching maximum brightness for the current quarter-year based on calculations by Warner. We switched to this presentation in lieu of ephemerides for reasons outlined in the 2021 October-December opportunities paper (Warner et al., 2021b), which centered on the potential problems with ephemerides generated several months before publication.

The initial list of targets started using the planning tool at

<https://www.minorplanet.info/php/callopplcdbquery.php>

where the search was limited to near-Earth asteroids only that were $V \leq 18$ for at least part of the quarter.

The list was then filtered to include objects that might be targets for the Goldstone radar facility or, if it were still operational, the Arecibo radar. This was based on the calculated radar SNR using

<http://www.naic.edu/~eriverav/scripts/index.php>

and assuming a rotation period of 4 hours (2 hours if $D \leq 200$ m) if a period was not given in the asteroid lightcurve database (LCDB; Warner et al., 2009). The SNR values are estimates only and assume that the radar is fully functional.

If an asteroid was on the list but failed the SNR test, we checked if it might be a suitable target for radar and/or photometry sometime through 2050. If so, it was kept on the list to encourage physical and astrometric observations during the current apparition. In most of those cases, the SNR values in the “A” and “G” columns are not for the current quarter but the year given in the Notes column. If a better apparition is forthcoming through 2050, the Notes column in Table I contains SNR values for that time.

The final step was to cross-reference our list with that found on the Goldstone planned targets schedule at

http://echo.jpl.nasa.gov/asteroids/goldstone_asteroid_schedule.html

It’s important to note that the final list in Table I is based on *known* targets and orbital elements when it was prepared. It is common for newly discovered objects to move in or out of the list. We recommend that you keep up with the latest discoveries by using the Minor Planet Center observing tools.

In particular, monitor NEAs and be flexible with your observing program. In some cases, you may have only 1-3 days when the asteroid is within reach of your equipment. Be sure to keep in touch with the radar team (through Benner’s email or their Facebook or

Twitter accounts) if you get data. The team may not always be observing the target but your initial results may change their plans. In all cases, your efforts are greatly appreciated.

For observation planning, use these two sites

MPC: <http://www.minorplanetcenter.net/iau/MPEph/MPEph.html>
JPL: <http://ssd.jpl.nasa.gov/?horizons>

Cross-check the ephemerides from the two sites just in case there is discrepancy that might have you imaging an empty sky.

About YORP Acceleration

Near-Earth asteroids are particularly sensitive to YORP acceleration. YORP (Yarkovsky–O’Keefe–Radzievskii–Paddack; Rubincam, 2000) is the asymmetric thermal re-radiation of sunlight that can cause an asteroid’s rotation period to increase or decrease. High precision lightcurves at multiple apparitions can be used to model the asteroid’s *sidereal* rotation period and see if it’s changing.

It usually takes four apparitions to have sufficient data to determine if the asteroid rotation rate is changing under the influence of YORP. This is why observing an asteroid that already has a well-known period remains a valuable use of telescope time. It is even more so when considering the BYORP (binary-YORP) effect among binary asteroids that has stabilized the spin so that acceleration of the primary body is not the same as if it would be if there were no satellite.

The Quarterly Target List Table

The Table I columns are

Num	Asteroid number, if any.
Name	Name assigned by the MPC.
H	Absolute magnitude from MPCOrb.
Dkm	Diameter (km) assuming $p_V = 0.2$.
Date	Date (mm dd.d) of brightest magnitude.
V	Approximate V magnitude at brightest.
Dec	Approximate declination at brightest.
Period	Synodic rotation period from summary line in the LCDB summary table.
Amp	Amplitude range (or single value) of reported lightcurves.
U	LCDB U (solution quality) from 1 (probably wrong) to 3 (secure).
A	Approximate SNR for Arecibo (if operational and at full power).
G	Approximate SNR for Goldstone radar at full power.
Notes	Comments about the object.

“PHA” is a potentially hazardous asteroid. For good measure, consider that astrometry and photometry have been requested to support Goldstone observations. The sources for the rotation period are given in the Notes column. If none are qualified with a specific period, then the periods from multiple sources were in general agreement. Higher priority should be given to those where the current apparition is the last one $V \leq 18$ through 2050 or several years to come.

Num	Name	H	D	Date	V	Dec	Period	Amp	U	A	G	Notes
	2011 TG2	20.3	0.259	10 06.4	16.6	+14				10	–	
177615	2004 HK33	17.73	0.845	10 16.4	14.9	–52				55	15	
422787	2001 WS1	16.84	1.27	10 23.6	14.9	+39				70	20	PHA
523823	2015BG311	18.43	0.612	10 24.0	16.2	+17						Last chance for small telescopes thru 2050.
312942	1995 EK1	17.43	0.97	10 24.1	15.2	+76	8.444	0.45	3	65	20	Erikson et al. (2000)
194268	2001 UY4	18.44	0.61	10 27.3	15.9	–15	6.8020	0.13 0.16	2	20	6	Monteiro et al. (2018)
186822	2004 FE31	17.93	0.771	11 09.5	15.9	–62				165	45	
217628	Lugh	16.62	1.41	11 14.9	14.7	–7	8.55	0.08	1	55	15	Wisniewski et al. (1997)
85713	1998 SS49	15.78	2.07	11 16.3	13.9	+45	5.370	0.06 0.18	2	65	19	Warner (2015)
	2019 OR1	20.8	0.206	11 18.0	16.6	+24				85	25	
99907	1989 VA	18.0	0.746	11 15.1	16.1	–19	2.5246	0.22 0.40	3	3	–	Pravec et al. (2017web) Visual obs. in 2025 10 29.3 V:16.7 +40
143947	2003 YQ117	15.39	2.48	11 21.5	14	–64				260	75	
	2005 LW3	21.62	0.141	11 24.3	13.3	+17				?	?	
	2009 HV58	19.6	0.357	11 29.6	16.7	–79				2415	690	
	1979 XB	18.6	0.566	12 01.8	17.3	–5				7		YORP target? 2036 06.4 V:17.1 –12.
	2013 PV2	20.18	0.274	12 05.9	16.4	–14				25	8	Good through end of 2022.
162474	2000 LB16	18.66	0.551	12 11.2	16.0	+39				35	10	
	2015 RN35	23.1	0.071	12 16.2	13.3	–22						
	2014 HK129	21.1	0.179	12 18.8	14.7	–23	>10	0.5	2	8625	2475	Thirouin et al. (2018)
	2013 YA14	23.6	0.057	12 24.5	15.3	+52				?	?	Last chance for small telescopes thru 2050.
	2010 XC15	21.43	0.154	12 26.8	13.3	+18						
199003	2005 WJ56	18.16	0.693	12 31.	16.7	+50	4.3825	0.09 0.15		3	5	Behrend (2007web) Last chance. Brightest on 2023 01 08.5 V:13.7 –16
226554	2003 WR21	19.64	0.351	12 31.	15.7	–13				20	6	Brightest 2023 01 02.3 V:15.6 +55

Table I. A list of near-Earth asteroids reaching brightest in 2022 October–December. PHA: potentially hazardous asteroid. Diameters are based on $p_V = 0.20$. The Date, V, and Dec columns are the mm/dd.d, approximate magnitude, and declination when at brightest. Amp is the single or range of amplitudes. The A and G columns are the approximate SNRs for an assumed full-power Arecibo (not operational) and Goldstone radars. The references in the Notes column are those for the reported periods and amplitudes. The “?” in the A/G columns are for when the SNR calculator failed for distances less than 0.01 au.

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