

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2021 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. We have changed the presentation of the “Radar-Optical Opportunities” section to include a list of potential radar targets as well as some that are in critical need of astrometric data and, if found, might also be targets for radar. These can have ephemeris errors on the order of tens to thousands of arcseconds and, despite the current surveys, have not been observed for several years. This makes them a double challenge: first to be found and, second, to determine astrometric positions and photometric properties.

We present several lists of asteroids that are prime targets for photometry and/or astrometry during the period 2021 October-December. The “Radar-Optical Opportunities” section has a new format that provides an expanded list of potential targets and no longer gives geocentric ephemerides.

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 CALL 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.

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

We refer you to past articles, e.g., Warner et al. (2021) 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 3.9 million observations for 15,000+ objects, making it one of the more useful sources for raw asteroid *time-series* lightcurve data.

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 $U = 1$ should be given higher priority over those rated $U = 2$ or 2+, but not necessarily over those with no period. 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.

An entry in bold italics is a near-Earth asteroid (NEA).

Number	Name	Brightest			Period	LCDB Data		U
		Date	Mag	Dec		Amp		
7328	Casanova	10	01.3	15.4	+7	9.122	0.31	2
7825	1991 TL1	10	01.4	15.4	+8	>10	0.05	2
6946	1980 RX1	10	01.8	15.2	-3	15.104	0.18	2
2972	Niilo	10	04.3	14.5	+5	8.592	0.12	2
5058	Tarrega	10	05.4	15.1	-10	4.983	0.57	2
666	Desdemona	10	06.4	12.5	+10	14.607	0.06-0.22	2+
6200	Hachinohe	10	06.5	14.9	-7	78.327	0.41	2
39317	2001 UU168	10	06.5	15.4	+13	86.895	0.73-0.75	2
3461	Mandelshtam	10	06.8	15.4	+1	2.848	0.20	2
5714	Krasinsky	10	06.9	15.1	+5	18.184	0.45	2
5093	Svirelia	10	10.6	15.3	+13	2.809	0.24	2
16009	1999 CM8	10	10.6	14.4	-4	16.7	0.54-0.65	2+
3277	Aaronson	10	11.5	14.6	-6	9.8	0.14	2+
1007	Pawlowia	10	14.8	14.2	+12	121	0.51	2
6083	Janeirabloom	10	18.6	15.5	+8	10.151	0.23	2
40717	1999 SC2	10	20.1	15.0	+10	3.436	0.11-0.22	2
995	Sternberga	10	20.8	12.8	+16	14.612	0.06-0.20	2+
6706	1988 VD3	10	21.3	15.2	+13	27.021	0.05	1
957	Camelia	10	23.5	13.8	+20	150	0.30	1+
4023	Jarnik	10	23.5	15.3	+13	4.776	0.27	2
9755	1990 RR2	10	26.5	15.5	+9	4.774	0.37	2
1913	Sekanina	10	27.4	15.0	+14	13.97	0.30-0.31	2+
2743	Chengdu	10	29.3	14.9	+26	8.321	0.45	2
2970	Pestaloizzi	11	02.1	15.5	+32	126.942	0.66	2
846	Lipperta	11	07.7	13.5	+17	1641	0.30	2
87024	2000 JS66	11	11.3	15.5	+21	27.6	1.52	2
1781	Van Biesbroeck	11	11.8	15.0	+19	6.385	0.45	2
6854	Georgewest	11	16.2	15.2	+17	3.64	0.66	2
4086	Podalirius	11	19.0	15.5	+20	10.43	0.08-0.16	2+
6887	Hasuo	11	24.4	15.0	+23	2.752	0.18	2
2837	Griboedov	11	25.0	15.4	+21	3.95		2
6659	Pietsch	11	25.1	15.4	+23	12.985	0.31-0.44	2
4214	Veralynn	11	26.3	15.3	+26	7.6	0.35	2-
1720	Niels	11	27.4	14.3	+20	250.9	0.61	2
6838	Okuda	11	29.0	14.8	+22	8.983	0.14-0.34	2+
6242	1990 OJ2	11	29.2	15.3	+21	5.475		2
6314	Reigber	12	05.5	15.3	+18	96.446		2
4660	Nereus	12	07.9	12.5	+69	15.1	0.6- 0.8	2
3550	Link	12	12.0	14.7	+23	12.371	0.21	2
163899	2003 SD220	12	13.2	13.8	+55	285	1.39- 2.5	2+
1450	Raimonda	12	14.0	14.5	+24	12.66	0.57	2
1091	Spiraea	12	18.6	15.2	+24	7.01	0.03	1+
2906	Caltech	12	20.3	14.4	+27	12.994	0.16-0.27	2+
4276	Clifford	12	24.3	15.5	+40	3.239	0.09	2
6662	1993 BP13	12	24.7	15.0	+22	>24	0.94	1
2336	Xinjiang	12	25.1	15.4	+24	37.299	0.12	2
7430	Kogure	12	30.0	14.4	+24	335.9	0.57	2

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.

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

You will have the best chance of success working objects with low amplitude and periods that allow covering at least half a cycle every night. 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. This reduction requires that you determine the period and the amplitude of the lightcurve; for long period objects that can be difficult. 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). This 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-G₁₂, introduced by Muinonen et al. (2010). It will be some years before H-G₁₂ becomes widely used, and hopefully not until a discontinuity flaw in the G₁₂ 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 about 50° 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. Catalogs such as CMC-15, APASS, or the MPOSC from *MPO Canopus* should not be used due to 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*. This is so that the lightcurve amplitude isn't significantly different. If necessary, the magnitudes for the 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.

For this table, the asteroid magnitudes are brighter than in others. This is because higher precision is required for this work 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
359	Georgia	10 01.6	0.26	11.8	+04	5.537	0.16	0.54 3
4856	Seaborg	10 03.0	0.04	15.0	+04	15.853		0.41 3
2972	Niilo	10 04.4	0.37	14.5	+05	8.592		0.12 2
312	Pierretta	10 04.6	0.46	12.4	+06	10.282		0.32 3
2004	Lexell	10 04.8	0.32	14.6	+05	5.443	0.42-0.51	3
1508	Kemi	10 06.0	0.54	14.7	+04	9.196	0.25-0.55	3
551	Ortrud	10 07.2	0.10	13.2	+06	17.416	0.14-0.19	3
1008	La Paz	10 07.2	0.53	14.4	+04	8.998	0.14-0.19	3
1848	Delvaux	10 08.1	0.53	14.7	+07	3.637	0.57-0.69	3
3673	Levy	10 10.2	0.47	14.5	+08	2.688		0.13 3
310	Margarita	10 11.7	0.78	14.3	+09	12.070	0.14-0.37	3
1143	Odysseus	10 11.7	0.30	15.0	+09	10.114	0.15-0.22	3
377	Campania	10 13.9	0.74	12.0	+10	11.664	0.14-0.27	3
279	Thule	10 16.5	0.55	14.3	+07	23.896	0.02-0.10	3
40717	1999 SC2	10 20.1	0.41	15.0	+10	3.436		0.22 2
454	Mathesis	10 23.0	0.15	13.1	+11	8.378	0.20-0.37	3
1447	Utra	10 23.0	0.32	14.7	+11	257.		0.63 2
460	Scania	10 23.6	0.31	13.6	+11	9.55		0.05 2-
223	Rosa	10 24.9	0.27	13.8	+11	20.283	0.06-0.13	3
1518	Rovaniemi	10 26.0	0.60	13.9	+13	5.249	0.25-0.26	3
1082	Pirola	10 26.2	0.94	14.0	+10	15.853	0.53-0.62	3
461	Saskia	10 26.4	0.64	14.4	+11	7.348	0.25-0.36	3
614	Pia	10 26.9	0.32	13.8	+13	4.572	0.21-0.42	3
1913	Sekanina	10 27.4	0.55	14.9	+14	13.97	0.30-0.31	2+
2379	Heiskanen	10 30.0	0.25	14.2	+13	3.76	0.17-0.23	3
151	Abundantia	11 05.0	0.26	12.5	+16	9.864	0.15-0.20	3
2193	Jackson	11 07.4	0.76	15.0	+19	4.754	0.23-0.24	3
846	Lipperta	11 07.7	0.18	13.5	+17	1641.		0.30 2
9513	1971 UN	11 08.0	0.97	15.7	+19			
907	Rhoda	11 09.7	0.94	13.1	+19	22.44	0.08-0.16	3-
3396	Muazzez	11 10.5	0.75	15.0	+19			
981	Martina	11 11.2	0.11	14.3	+18	11.267	0.15-0.24	2
494	Virtus	11 13.9	0.75	13.4	+20	5.57	0.03-0.12	2+
435	Ella	11 15.9	0.75	12.7	+20	4.623	0.30-0.38	3
1199	Geldonia	11 19.0	0.09	14.2	+19	28.3		0.11 2-
311	Claudia	11 22.0	0.61	13.8	+18	7.532	0.16-0.89	3
2828	Iku-Turso	11 22.9	0.72	14.9	+19			0.60
1911	Schubart	11 26.0	0.44	14.7	+22	11.915	0.11-0.22	2
1720	Niels	11 27.4	0.67	14.3	+20	9.976		0.15 1
396	Aeolia	11 27.5	0.17	14.3	+21	14.353		0.36 3
322	Phaeo	11 27.8	0.74	11.7	+23	17.584	0.13-0.20	3
1289	Kutaissi	11 28.9	0.66	14.5	+19	3.60	0.20-0.42	3
6838	Okuda	11 29.0	0.28	14.8	+22	8.983		0.14 2+
2571	Geisei	12 02.1	0.14	14.8	+22	7.823		0.50 3-
197	Arete	12 04.1	0.83	13.0	+20	6.608	0.10-0.16	3
1801	Titicaca	12 04.1	0.60	14.8	+20	3.211		0.50 3
106	Dione	12 05.4	0.50	11.1	+24	16.210	0.08-0.18	3
514	Armida	12 06.1	0.49	13.2	+24	21.851	0.16-0.27	3
1001	Gaussia	12 07.6	0.35	13.4	+24	20.99	0.11-0.16	3
586	Thekla	12 08.0	0.39	13.2	+22	13.670	0.24-0.30	3
42	Isis	12 09.1	0.68	10.7	+21	13.590	0.14-0.32	3
1666	van Gent	12 09.5	0.31	14.6	+23	4.165	0.23-0.42	3
857	Glasenappia	12 12.0	0.21	14.0	+23	8.20	0.27-0.92	3
3550	Link	12 12.0	0.21	14.7	+23	12.371		0.21 2
	2019 CT11	12 12.9	0.42	14.2	+24			
1517	Beograd	12 13.3	0.85	14.9	+26	6.943	0.18-0.23	2
1450	Raimonda	12 13.9	0.50	14.4	+24	12.66		0.57 2
936	Kunigunde	12 14.0	0.33	15.0	+24	8.80		0.25 2
270	Anahita	12 17.1	0.34	11.2	+23	15.06	0.25-0.32	3
1817	Katanga	12 21.6	0.31	14.4	+24	8.481	0.22-0.42	3
6662	1993 BP13	12 24.7	0.65	15.0	+22	>24.		0.94 1
517	Edith	12 29.1	0.14	12.8	+23	9.275	0.08-0.18	3
1075	Helina	12 29.2	0.33	14.4	+22	44.9	0.64-0.91	3-
580	Selene	12 29.3	0.13	14.1	+23	9.47		0.27 3-
7430	Kogure	12 30.0	0.27	14.3	+24			
550	Senta	12 31.0	0.74	13.3	+21	20.555	0.3	0.41 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 $\geq$ 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			U
		Date	Mag	Dec	Period	Amp		
891	Gunhild	10 01.5	14.1	-16	11.892	0.18-0.37	3-	
359	Georgia	10 01.6	11.8	+4	5.537	0.14-0.54	3	
1830	Pogson	10 03.7	15.0	+0	2.57	0.07-0.18	3	
2209	Tianjin	10 05.6	14.7	+2	9.47	0.41-0.42	3	
551	Ortrud	10 07.2	13.2	+6	17.416	0.14-0.19	3	
100	Hekate	10 10.5	11.5	-2	27.066	0.11-0.23	3	
764	Gedania	10 11.9	13.9	+19	24.968	0.01-0.35	3-	
2535	Hameenlinna	10 12.0	14.9	+5	3.231	0.07-0.11	3	
111	Ate	10 12.5	11.6	+14	22.072	0.08-0.18	3	
701	Oriola	10 16.1	13.6	+15	9.09	0.20-0.37	3	
788	Hohensteina	10 16.7	13.7	+1	37.137	0.10-0.18	3	
259	Aletheia	10 21.1	12.8	-1	8.143	0.09-0.12	3	
1577	Reiss	10 23.1	14.3	+3	4.505	0.12-0.20	3	
901	Brunsia	10 25.0	13.1	+18	3.136	0.09-0.28	3	
169	Zelia	10 25.5	11.9	+18	14.537	0.13-0.17	3	
911	Agamemnon	10 31.3	14.8	+36	6.592	0.04-0.29	3	
6249	Jennifer	10 31.3	13.6	+20	4.957	0.06-0.49	3	
4223	Shikoku	11 01.0	14.8	+25	9.137	0.12-0.19	3	
2162	Anhui	11 03.3	14.5	+9	8.105	0.14-0.18	3	
4935	Maslachkova	11 04.3	14.9	+4	2.902	0.23	3	
626	Notburga	11 09.2	12.1	+62	19.353	0.10-0.21	3	
907	Rhoda	11 09.9	13.1	+19	22.44	0.06-0.16	3-	
577	Rhea	11 10.2	13.9	+25	12.249	0.19-0.24	3-	
796	Sarita	11 11.0	11.1	+31	8.175	0.27-0.33	3	
1146	Biarmia	11 11.5	14.8	+11	5.47	0.14-0.32	3	
5143	Heracles	11 11.5	14.2	+37	2.706	0.05-0.22	3	
159857	2004 LJ1	11 12.9	14.3	+6	2.725	0.15-0.59	3	
613	Ginevra	11 14.5	13.5	+28	12.906	0.12-0.20	3	
3361	Orpheus	11 15.6	14.3	-32	3.533	0.17-0.32	3	
535	Montague	11 17.5	12.7	+14	10.248	0.18-0.25	3	
2460	Mitlincoln	11 19.4	14.7	+13	3.007	0.03-0.20	3	
1096	Reunerta	11 20.4	13.9	+14	13.036	0.20-0.39	3	
1717	Arlon	11 20.6	14.2	+31	5.148	0.06-0.12	3	
2323	Zverev	11 20.7	14.9	+25	3.921	0.28-0.39	3	
3687	Dzus	11 23.3	14.9	+13	58.12	0.06-0.15	3-	
530	Turandot	11 24.6	13.8	+10	19.96	0.10-0.17	3-	
1346	Gotha	11 24.8	14.2	-3	2.641	0.10-0.16	3-	
288	Glauke	11 25.1	14.2	+15	1170	0.36- 0.9	3	
833	Monica	11 26.0	15.0	+35	12.09	0.11-0.21	3	
3425	Hurukawa	11 27.3	14.9	+31	24.84	0.17-0.47	3-	
1093	Freda	11 27.6	13.8	+28	19.67	0.06-0.21	3	
1189	Terentia	12 01.6	13.7	+29	19.308	0.32-0.38	3	
3447	Burckhalter	12 01.9	14.9	+58	59.8	0.30-0.39	3	
978	Aidamina	12 03.2	14.0	+3	10.099	0.09-0.24	3	
197	Arete	12 03.9	13.1	+20	6.608	0.10-0.16	3	
1888	Zu Chong-Zhi	12 04.1	14.2	+21	11.053	0.28-0.56	3	
308	Polyxo	12 05.0	11.9	+16	12.029	0.08-0.15	3-	
514	Armida	12 06.0	13.2	+24	21.851	0.16-0.27	3	
1394	Algoa	12 07.8	14.9	+18	2.768	0.20-0.21	3	
586	Thekla	12 08.0	13.2	+22	13.67	0.24-0.30	3	
2577	Litva	12 15.2	14.9	-26	2.813	0.14-0.36	3	
467	Laura	12 20.9	14.5	+32	70.63	0.13-0.15	3	
1817	Katanga	12 21.7	14.4	+24	8.481	0.22-0.30	3	
301	Bavaria	12 27.4	14.3	+18	12.253	0.25-0.31	3	
126	Velleda	12 28.9	12.3	+28	5.367	0.07-0.22	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 have switched to this presentation in lieu of ephemerides for chosen objects for several reasons.

The most important among them is that for some objects, those marked “Astrometry needed,” the last observations may have been many years ago and so the ephemeris uncertainties may be extremely large. A case in point, and what prompted the change, is 2016 XG1. Our positions and magnitudes for 2021 November were similar to those from the Minor Planet Center. However, the JPL Horizons ephemeris showed the asteroid almost 3 magnitudes fainter and a difference of many hours in Right Ascension.

Another reason is that the previous ephemeris listings were for geocentric positions. For close-approach apparitions, the offsets between those and topocentric (those from a given location on the Earth’s surface) could be significant and, furthermore, the orbital elements may have been updated since our ephemerides were generated, resulting in significant changes in positions and/or magnitudes.

The initial list started with one generated by the planning tool at

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

where the search was limited to only near-Earth asteroids at $V \leq 18$ during 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.

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 into, out of, or up the list and become radar targets on short notice. 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>

It's good to cross-check the ephemerides from the two sites just in case there is a situation such as that with 2016 XG1 mentioned above.

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.
Dia	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.

Rows in bold were listed on the Goldstone scheduling page.

"PHA" is a potentially hazardous asteroid. "Requested" in the notes field indicates that astrometry and/or photometry were requested to support Goldstone observations. "Astrometry needed" is given for those objects that were last observed several years ago and for which ephemerides uncertainties given by the MPC can be in the tens to thousands of arcseconds.

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.

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Num	Name	H	Dia	Date	V	Dec	Period (h)	Amp	U	A	G	Notes
363027	1998 ST27*	19.5	0.375	10 01.1	17.7	22	3	0.1	2			Next: 2024 Oct; V ~12.9. Binary and period from Benner et al. (2001).
312070	2007 TA19*	19.4	0.391	10 01.2	17.6	-14						Next: 2034 Oct; V ~ 17.7.
	2014 TM*	26.2	0.017	10 02.6	17.6	22				585	165	
	2017 TS3*	22.1	0.114	10 28.4	17.5	70				65	18	Astrometry/photometry requested.
7341	1991 VK	16.8	1.273	10 30.9	16.3	17	4.2096	0.21 0.7	3	20	5	Next: 2022/02; V ~ 14.8. Pravec et al. (1998web), Vaduvescu et al. (2017), and Warner (2016) are all from 2016 or earlier.
	2019 XS*	23.7	0.053	11 10.0	14.5	-1				3220	920	SNR for 0.01 au; min distance is 0.004 au.
87024	2000 JS66*	18.6	0.561	11 11.3	15.5	21	27.6	1.52	2	19	5	Pravec et al. (2004web). Next: 2038/10; V ~ 16.1.
	2004 UE*	21	0.188	11 12.1	16.0	-21	5.6	0.98	2+	580	165	PHA. Astrometry/photometry requested. Gandolfi et al. (2009).
159857	2004 LJ1*	15.4	2.438	11 12.9	14.3	6	2.7247	0.15 0.59	3	40	10	2038/11; V ~ 8.1. Galad et al., (2005); Warner (2015).
	2017 WP*	23.1	0.072	11 15.1	17.6	-9				58	16	Astrometry needed.
138852	2000 WN10	20.2	0.274	11 15.2	17.9	-32	4.4622	0.38 0.44	3	2		Dates/Dec about same every year through 2050. Pravec et al. (2011web);
	3361 Orpheus*	19.0	0.464	11 15.6	14.3	-32	3.5327	0.17 0.32	3	935	265	PHA. Photometry requested. NHATS. Pravec et al. (2019web); Skiff et al. (2019).
	2010 VK139*	23.7	0.053	11 15.7	17.1	13	0.0299522	0.5	3	90	25	Astrometry/photometry requested. Birtwhistle (2011).
	2015 FF37*	18.7	0.540	11 19.2	17.2	62				45	10	Last observed: 2019; Astrometry needed.
374855	2006 VQ13*	20.0	0.297	11 19.6	17.6	2				6	2	Last at V <18 though 2050.
	2009 WB105*	23.5	0.061	11 25.0	16.9	22				30	10	Circumstances repeat about every 3 years.
	2017 KM27*	22.8	0.083	11 25.5	16.2	55				1890	540	Last at V < 18 through 2050.
152742	1998 XE12*	19.1	0.450	11 25.5	17.5	72				2		Next: 2024/01; V ~ 17.1.
	2007 TC23*	20.5	0.236	11 26.0	17.7	20				2		Astrometry needed. Last V < 18 through 2050.
	2002 TP69*	21.9	0.124	11 26.1	16.7	1				30	8	Last observed 2003. Last V < 18 through 2050.
516396	2000 WY28*	20.1	0.283	11 26.1	17.2	26				1		Astrometry needed. Last V < 18 through 2050.
531914	2013 BW76*	18.5	0.593	12 01.0	18.0	-14				3		Next: 2024/11; V ~ 17.4.
	1994 WR12*	22.3	0.104	12 02.2	16.8	46				60	15	Next: 2046/11; V ~ 14.0.
	4660 Nereus*	18.3	0.647	12 07.9	12.5	69	15.1	0.6 0.8	2	15100	4300	Photometry desirable. NHATS. Ishibashi et al. (2000); Brozovic et al. (2009).
518678	2008 UZ94*	17.4	0.984	12 08.1	15.1	-51				610	175	PHA. Astrometry/photometry requested.
480883	2001 YE4*	20.7	0.215	12 10.1	17.2	75				14	4	Last observed 2017; Next: 2026/12; V ~ 17.5.
	163899 2003 SD220*	17.7	0.873	12 13.2	13.8	55	285	1.39 2.5	2+	29600	8500	PHA. Photometry requested. NHATS. Warner (2016); Aznar et al. (2018, 173.4 h); Skiff et al. (2019, 280 h); Warner and Stephens (2019, 125 h).
363505	2003 UC20*	18.4	0.621	12 19.1	17.6	-21	29.6	0.88	2+	16	4	Last observed 2017; Next 2023/11; V ~ 14.2. Pravec et al. (2019web).
	2018 AH*	22.5	0.093	12 30.4	18.0	-5				150	40	Last observed 2018; Astrometry needed.

Table I. A list of near-Earth asteroids reaching brightest in the fourth quarter of 2021. * Favorable apparition. PHA: potentially hazardous asteroid. NHATS: Near-Earth Object Human Space Flight Accessible Targets Study.

The diameters (Dia column) are kilometers and based on an assumed albedo of 0.20. The date, V, and Dec columns give, respectively, the mm/dd.d, approximate magnitude, and declination when the asteroid is brightest. The Amp column gives the single or range of amplitudes. The A and G columns are, respectively, 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.

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