TARGET ASTEROIDS! OBSERVING CAMPAIGNS FOR JULY THROUGH SEPTEMBER 2015

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Asteroids campaigns to be conducted by the *Target Asteroids!* program during the July through September 2015 quarter are described. In addition to asteroids on the original *Target Asteroids!* list of easily accessible spacecraft targets, an effort has been made to identify other asteroids that are 1) brighter and easier to observe for small telescope users and 2) analogous to (101955) Bennu and (162173) 1999 JU3, targets of the OSIRIS-REx and Hayabusa-2 sample return missions.

Introduction

The *Target Asteroids!* program strives to engage telescope users of all skill levels and telescope apertures to observe asteroids that are viable targets for robotic sample return. The program also focuses on the study of asteroids that are analogous to (101955) Bennu and (162173) 1999 JU3, the target asteroids of the NASA OSIRIS-REx and JAXA Hayabusa-2 sample return missions respectively. Most target asteroids are near-Earth asteroids (NEA) though observations of relevant Main Belt asteroids (MBA) are also requested.

Even though many of the observable objects in this program are faint, acquiring a large number of low S/N observations allows many important parameters to be determined. For example, an asteroid's phase function can be measured by obtaining photometry taken over a wide range of phase angles. The albedo can be constrained from the phase angle observations, as there is a direct correlation between phase function and albedo (Belskaya and Shevchenko (2000). The absolute magnitude can be estimated by extrapolating the phase function to a phase angle of 0°. By combining the albedo and absolute magnitude, the size of the object can be estimated.

An overview of the *Target Asteroids!* program can be found at Hergenrother and Hill (2013).

Current Campaigns

Target Asteroids! plans to conduct a number of dedicated campaigns on select NEAs and analog carbonaceous MBAs during the quarter. These campaigns have a primary goal of conducting photometric measurements over a large range of phase angles.

Target Asteroids! objects brighter than V = 17.0 are presented in detail. A short summary of our knowledge of each asteroid and 10-day (shorter intervals for objects that warrant it) ephemerides are presented. The ephemerides include rough RA and Dec positions, distance from the Sun in AU (r), distance from Earth in AU (Δ), V magnitude, phase angle in degrees (PH) and elongation from the Sun in degrees (Elong).

We ask observers with access to large telescopes to attempt observations of spacecraft accessible asteroids that are between V magnitude ~17.0 and ~20.0 during the quarter (contained in the table below).

Asteroid Number	Name	Peak V Mag	Time of Peak Brightness
(7350)	1993 VA	17.4	late Aug
(52381)	1993 HA	18.2	late Nov
(65717)	1993 BX3	19.9	mid Sep
(89136)	2001 US16	19.6	late Jul
(163000)	2001 SW169	16.6	early Oct
(164221)	2004 QE20	19.0	early Jul
(341050)	2007 HZ	19.8	mid Sep
(350713)	2001 XP88	17.9	late Jul

The campaign targets are split up into two sections: carbonaceous MBAs that are analogous to Bennu and 1999 JU3; and NEAs analogous to the Bennu and 1999 JU3 or provide an opportunity to fill some of the gaps in our knowledge of spacecraft targets (examples include very low and high phase angle observations, phase functions in different filters and color changes with phase angle).

The ephemerides listed below are just for planning purposes. In order to produce ephemerides for your observing location, date and time, please use the Minor Planet Center's Minor Planet and Comet Ephemeris Service:

http://www.minorplanetcenter.net/iau/MPEph/MPEph.html

or the *Target Asteroids!* specific site created by Tomas Vorobjov and Sergio Foglia of the International Astronomical Search Collaboration (IASC) at

http://iasc.scibuff.com/osiris-rex.php

Analog Carbonaceous Main Belt Asteroid Campaigns

(442) Eichsfeldia (a=2.35 AU, e=0.07, i=6.1°, H = 10.0)
Not an obvious member of any of the major inner Main Belt carbonaceous asteroid families, (442) Eichsfeldia is an example of a carbonaceous (Ch-type) background object. Past studies suggested that it was a member of the Vesta family but its type and very low albedo (0.04) make that very unlikely.

This quarter Eichsfeldia covers a range of phase angles from 20° to an extremely low 0.2° at opposition on August 9. It is also at its brightest that day at V = 12.6. Lightcurve photometry found a period of 11.88 h and amplitude of 0.24-0.38 magnitudes. Filter photometry is especially requested to detect color changes at different phase angles.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 40	-12 15	1.49	2.32	13.6	18	135
07/11	21 37	-12 56	1.42	2.33	13.4	14	146
07/21	21 31	-13 54	1.37	2.34	13.2	10	157
07/31	21 23	-15 04	1.34	2.35	12.9	5	169
08/10	21 14	-16 18	1.34	2.35	12.6	0	179
08/20	21 04	-17 29	1.36	2.36	13.0	6	167
08/30	20 57	-18 29	1.41	2.37	13.3	10	155
09/09	20 51	-19 16	1.49	2.38	13.6	14	144
09/19	20 49	-19 47	1.58	2.38	13.8	18	134
09/29	20 49	-20 02	1.68	2.39	14.1	20	124

Near-Earth Asteroid Campaign Targets

(4055) Magellan (a=1.82 AU, e=0.33, i=23.3°, H = 14.5)
Over 12,000 NEAs are known today with ~1000 being discovered every year. The vast majority of discoveries are by semi-automated wide-field surveys employing CCD cameras and banks of computers. When Magellan was discovered back in 1985 things were very different. Back then only ~85 NEAs were known and none had been discovered with a CCD. Photographic film scanned visually with a stereomicroscope was the detection method of choice at the time.

Typical of early NEA discoveries, Magellan is a large object (2.8 km diameter and albedo of 0.33) that routinely gets bright. This quarter Magellan ranges in brightness from V = 15.4 to 12.2 and covers a range of phase angles from 49° to 3°. Spectrally it is a V-type suggesting it may be a piece of the large Main Belt asteroid Vesta. It rotates once every 6.38 h with a lightcurve amplitude of ~0.6 magnitudes.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	20 48	+41 43	0.51	1.27	15.4	49	108
07/11	21 04	+42 40	0.46	1.25	15.1	49	111
07/21	21 21	+42 06	0.40	1.24	14.8	48	115
07/31	21 38	+39 23	0.35	1.23	14.4	45	121
08/10	21 57	+33 33	0.30	1.23	13.9	40	130
08/20	22 15	+23 24	0.26	1.23	13.3	29	144
08/30	22 33	+08 46	0.24	1.24	12.7	15	162
09/09	22 50	-07 26	0.25	1.26	12.3	4	176
09/19	23 07	-20 45	0.29	1.28	13.2	16	159
09/29	23 22	-29 21	0.35	1.31	14.0	26	146

(68278) 2001 FC7 (a=1.44 AU, e=0.11, i=2.6°, H = 18.3)
2001 FC7 may not get as bright as some of the other NEA campaign objects this quarter but as a low delta-V carbonaceous asteroid it is worthy of special attention. Low delta-V means it is requires less energy to sortie to and return from the asteroid.

Little is known about 2001 FC7 other than a spectral C-type classification. Phase function photometry will help constrain its albedo and any phase angle dependent color changes. Minimum phase angle of 5.2° occurs on August 3. Peak brightness also happens at that time (V = 16.4).

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 05	-18 07	0.34	1.31	17.8	26	145
07/11	21 09	-19 22	0.31	1.30	17.3	20	154
07/21	21 07	-21 08	0.28	1.29	16.9	13	164
07/31	21 02	-23 09	0.27	1.28	16.5	6	173
08/10	20 55	-25 03	0.27	1.28	16.5	8	170
08/20	20 49	-26 24	0.28	1.27	16.9	16	160
08/30	20 47	-27 01	0.29	1.27	17.3	24	150
09/09	20 51	-26 53	0.32	1.27	17.6	30	141
09/19	20 59	-26 04	0.35	1.27	18.0	35	134
09/29	21 12	-24 41	0.39	1.28	18.3	39	127

(85989) 1999 JD6 (a=0.88 AU, e=0.63, i=17.1°, H = 17.1)
1999 JD6 passes within 0.016 AU of Earth on July 20. During its flyby the asteroid will peak at magnitude V = 14.6 and cover a range of phase angles from 109° to 16°.

Taxonomic classification is all over the place with K, L and Cg types being assigned to it. Its albedo is rather dark at 0.075. Lightcurve observations show a 7.7 hr rotation period and large amplitude ~1.2 magnitudes.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	21 26	+14 59	0.29	1.20	16.5	45	124
07/05	21 27	+17 18	0.24	1.17	16.1	45	125
07/09	21 28	+20 27	0.20	1.14	15.6	46	126
07/13	21 27	+25 12	0.15	1.11	15.0	49	125
07/17	21 24	+33 30	0.11	1.07	14.4	55	120
07/21	21 13	+51 21	0.07	1.07	13.8	70	106
07/25	12 48	+83 31	0.05	1.00	14.7	110	68
07/29	09 52	+39 56	0.07	0.96	19.7	151	27

(206378) 2003 RB (a=1.79 AU, e=0.44, i=6.7°, H = 18.7)
Broadband filter photometry suggests 2003 RB is a carbonaceous NEA. Other than that little else is known of its physical characteristics. This quarter 2003 RB peaks at a rather bright V = 13.8 in mid-August. Minimum phase angle is reached a week earlier at 8°. A maximum phase angle of 88° occurs in mid-September.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	20 39	-33 52	0.33	1.31	17.9	22	151
07/11	20 51	-32 58	0.25	1.25	17.1	19	157
07/21	21 04	-30 44	0.19	1.19	16.3	15	162
07/31	21 22	-25 24	0.13	1.14	15.2	11	168
08/10	21 55	-12 11	0.08	1.09	14.1	9	170
08/20	23 04	+21 07	0.05	1.06	14.0	36	142
08/30	01 46	+57 18	0.07	1.03	15.4	74	103
09/09	04 45	+63 05	0.10	1.01	16.8	87	88
09/19	06 10	+60 19	0.14	1.00	17.5	87	85
09/29	06 50	+57 27	0.18	1.01	17.8	82	88

2011 UW158 (a=1.62 AU, e=0.38, i=4.6°, H = 19.5)
2011 UW158 will brighten to magnitude 14.7 on July 21 as it passes within 0.016 AU of Earth. A large range of phase angles can be observed this quarter (from 110° to 18°). Little is known of about this object so all types of photometry is welcome.

DATE	RA	DEC	Δ	r	V	PH	Elong
07/01	12 36	-19 29	0.07	1.03	16.4	79	97
07/11	12 44	-04 50	0.03	1.01	15.5	94	84
07/21	14 13	+71 45	0.02	1.01	14.7	108	72
07/31	00 10	+54 58	0.04	1.02	15.6	84	94
08/10	00 21	+44 38	0.08	1.04	16.4	70	107
08/20	00 20	+39 47	0.11	1.07	16.8	57	118
08/30	00 15	+35 58	0.14	1.10	17.2	46	129
09/09	00 08	+32 10	0.17	1.14	17.4	35	140
09/19	00 00	+28 09	0.21	1.19	17.6	25	150
09/29	23 55	+24 08	0.26	1.24	17.9	18	157

References

Belskaya, I., Shevchenko, V. (2000). "The Opposition Effect of Asteroids". *Icarus* **147**, 94-105.

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