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DEEP-South: Preliminary Photometric Results from the KMTNet-CTIO

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Abstract. Korea Astronomy and Space Science Institute (KASI) successfully completed the development of Korea Microlensing Telescope Network (KMTNet, Park *et al.* 2012) in mid-2015, following which it conducted test runs for several months. 'DEep Ecliptic Patrol of the Southern sky' (DEEP-South, Moon *et al.* 2015), which will be used for asteroid and comet studies, will not only characterize targeted asteroids, carrying out blind surveys toward the sweet spots, but will also mine the data of such bodies using the KMTNet archive. We report preliminary lightcurves of four Potentially Hazardous Asteroids (PHAs) from test runs at KMTNet-CTIO in the February - May 2015 period.

Keywords. minor planets, asteroids

1. Overview

KMTNet consists of three identical 1.6 m prime focus telescopes, each equipped with 18k × 18k mosaic CCDs, resulting in 2 × 2 degrees of field of view. The three stations (CTIO in Chile, SAAO in South Africa and SSO in Australia) are longitudinally well separated, and thus will benefit from 24-h continuous monitoring of the southern sky. We awarded 45 full nights every year at each site for five years (2015 - 2019) during the "non-bulge season". We carried out test runs at KMTNet-CTIO in the fall 2015 season, and plan to carry out normal operation at three KMTNet stations from early October 2015.

2. Test run targets

The primary scientific objective of DEEP-South is physical characterization of km-class PHAs at opposition. We conducted targeted observations to achieve this goal during our test runs in the February - May period in 2015. The five different observation modes for DEEP-South are: Opposition Census (OC), Sweet spot survey (S1), Ecliptic survey (S2), NEOWISE follow-up (NW), and Target of Opportunity observation (TO) (Moon *et al.* 2015). Target information and observed dates are shown in Table 1.

3. Lightcurves

We present four individual PHAs' lightcurves obtained from the test runs in Figure 1. All figures were drawn as composite lightcurve folded with their synodic rotational periods. The horizontal axis of each lightcurve represents rotational phase, and the vertical axis represents differential magnitude between instrumental magnitude of an asteroid

Table 1. Target asteroids obtained from test run at KMTNet-CTIO in February - May 2015 period

Class	Objects	H	P_{rot} (hr)	Observing dates (UT)
PHA	4015 Wilson-Harrington	15.99	3.5736	24 Feb 2015
	5189 (1990 UQ)	17.9	**6.65**	26 Feb, 08, 10 Mar, 11, 13 Apr 2015
	12923 Zephyr (1999 GK4)	15.8	3.891	26 Feb, 08, 12 Mar, 07, 09 Apr 2015
	52760 (1998 ML14)	17.5	14.28	02 Mar 2015
	53319 (1999 JM8)	15.2	136.	14 Feb 2015
	53426 (1999 SL5)	17.1	**2.93**	12 Feb, 04, 14, 16 Mar, 22, 24 Apr, 04, 06 May 2015
	89830 (2002 CE)	14.9	2.6149	11, 13, 22, 24 Apr 2015
	99248 (2001 KY66)	16.4	19.7	12, 14, 26 Feb, 02 Mar 2015
	136617 (1994 CC)	17.7	2.3886	24 Feb 2015
	186844 (2004 GA1)	17.4	unknown	14 Feb 2015
	212546 (2006 SV19)	17.7	unknown	28 Feb, 06, 10 Mar 2015
	242450 (2004 QY2)	14.7	unknown	11, 13 Apr 2015
	311044 (2004 BB103)	17.1	unknown	14 Feb 2015
	363790 (2005 JE46)	17.7	unknown	02 Mar 2015
	385186 (1994 AW1)	17.6	2.5193	14 Feb, 12, 16 Mar 2015
	414287 (2008 OB9)	17.7	42.5	28 Feb, 06 Mar, 11, 13 Apr 2015
	430440 (2000 OH)	17.4	unknown	12 Feb, 04, 14 Mar, 07, 09 Apr 2015
	(2007 CA19)	17.4	unknown	14 Feb 2015
NHATS	293726 (2007 RQ17)	22.6	unknown	24, 26, 30 May, 01 Jun 2015
	416186 (2002 TD60)	19.3	2.8513	10, 14, May 2015
	436724 (2011 UW158)	19.5	**0.61**	26, 28, 30 Apr, 02, 08, 12, 16, 18, 20, 22, 26, 28 May 2015
Comet	119P/Parker-Hartley	-	-	06 Mar 2015
	269P/Jedicke	-	-	06 Mar 2015
	2014 W11 (PANSTARRS)	-	-	06 Mar 2015
	2015 A1 (PANSTARRS)	-	-	06 Mar 2015

Notes:
Rotational periods P_{rot} (hr) adopted from LCDB (Warner *et al.* 2009) (Rev. 2015-May). For three objects (1990 UQ, 1999 SL5, and 2011 UW158) marked with boldface, P_{rot} were obtained for the first time.

and an average magnitude of comparison stars. This is the first time that we have derived the rotational periods of asteroids 5189 (1990 UQ) and 53426 (1999 SL5) from our observations. 385186 (1994 AW1) is one of the well-known binary NEAs, with a primary rotational period of 2.5193 hr (Pravec & Hahn 1997).

Asteroid 436724 (2011 UW158) is listed on the Jet Propulsion Laboratory (JPL)'s NHATS (Near-Earth Object Human Space Flight Accessible Target Study) table; its size has been estimated to be ~300 × 600 m (H = 19.5) with the radio telescope at Arecibo†. Based on our time series photometry at KMTNet-CTIO in April 2015, we

† Solar System Studies at Arecibo Observatory, http://www.naic.edu/~pradar/news.php#2015

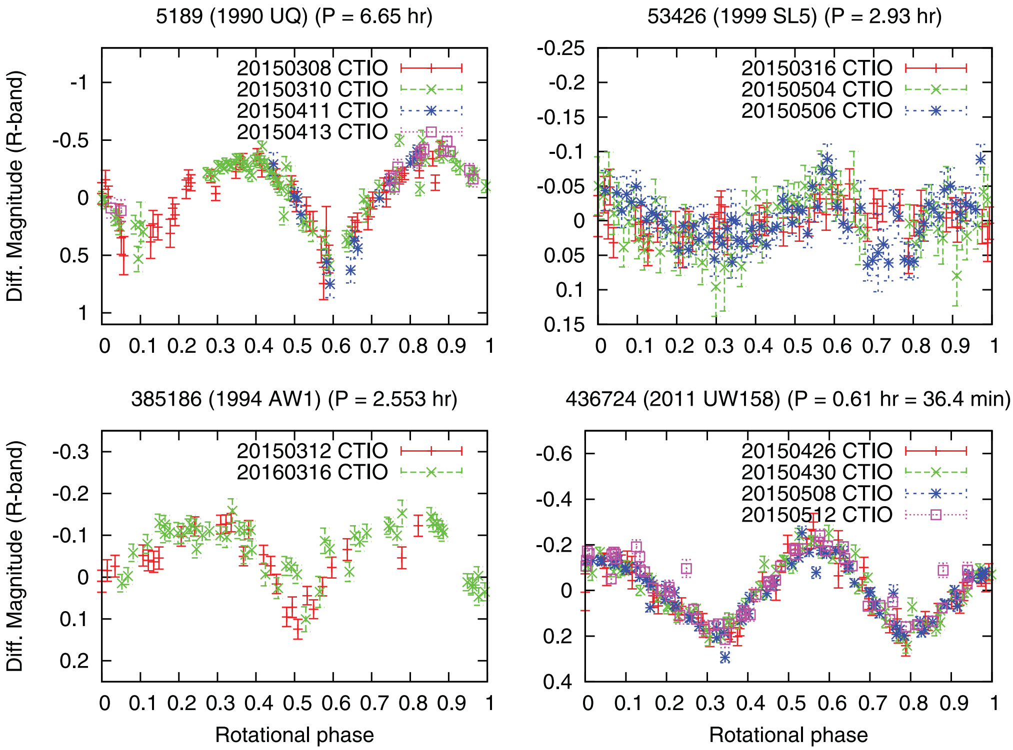

Figure 1. Composite lightcurves of 5189 (1990 UQ), 53426 (1999 SL5), 385186 (1994 AW1) and 436724 (2011 UW158) folded with their rotational periods.

found a synodic rotational period of 0.61 hr (~36.4 min) and amplitude of 0.5 mag, for the first time. The 3D-shape and rotational period of this elongated rapid rotator was confirmed by Goldstone-GBT radar observations‡ in July 2015.

4. Implications

Round-the-clock observations with the KMTNet telescopes are considered to be optimized for spin characterization of asteroids, including tumbling and slowly-rotating bodies, and are expected to facilitate the debiasing of previously reported lightcurve observations. For the sake of efficiency, we implemented an automated observation scheduler, SMART (Scheduler for Measuring Asteroids RoTation, Kim 2014), which is designed to conduct follow-up observations on time with another, to effectively fill in the period gaps. It automatically updates ephemerides, checks priorities, prepares target lists, and sends a suite of scripts to site operators. We also revised the mover detection software, MODP (Moving Object Detection Program, Bae *et al.* 2005) and ASAP (Asteroid Spin Analysis Package, Kim 2014) that aids to find a set of comparison stars in each CCD image, to derive spin parameters and reconstruct lightcurve simultaneously in a semi-automatic manner (Yim *et al.* 2015). In addition to spin characterization of a large number of asteroids and comets, either in near Earth space or in the main-belt, the KMTNet software subsystem with near-real time data reduction and analysis capabilities is expected to serendipitously discover and characterize outer Solar System objects at the same time.

‡ Goldstone Radar Observations Planning, http://echo.jpl.nasa.gov/asteroids/2011UW158/2011UW158_planning.html

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