CHARACTERIZATION OF EARTH CLOSING APPROACHING NEAS USING OWL-NET

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ABSTRACT

OWL-Net (Optical Wide-field patroL Network) is consists of five identical 0.5 m wide-field telescopes located in Mongolia, Morocco, Israel, United States, and South Korea. They are being operated in fully autonomous mode with the minimum human intervention. It could be practical to carry out time-series photometry of Earth closing approaching bright NEAs such as 2014 JO 25, 1981 ET3, 2012 TC4 and 1983 TB. We derived the photometric lightcurves for PHA 2014 JO25 and 3200 Phaethon (1983 TB) which passed by the Earth at a lunar distance (LD) of only 4.6 and 27 LD, respectively. In this paper, we introduce the system design and report the preliminary observation results on the NEAs.

1 OWL-NET

The primary goal of the OWL-Net is to maintain orbital information of LEO satellites and to monitor the area of GEO satellites by pure optical observations [1]. To overcome limits of the optical observations, we managed a global network of telescopes which run in a fully autonomous way (see Fig. 1).

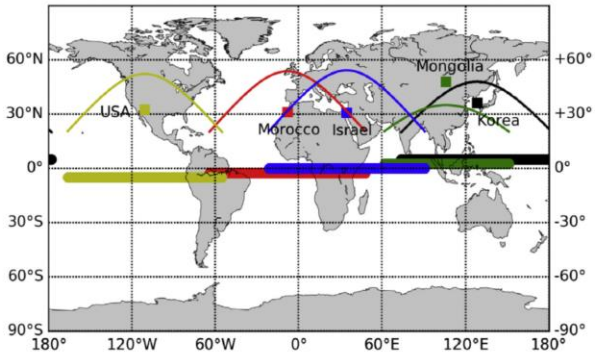

Figure 1. Site Location Map (colored squares) of the OWL-Net Telescopes. GEO Belt Elevation (colored lines) Angle and Coverage (centered lines) are also Shown when the Elevation Angle is Greater than 20° (cited from [1])

1.1 Telescope and detection system

The OWL-Net telescopes equipped with 4K × 4K CCDs provide a 1 square degree field of view with a 0.98 arcsec/pixel plate scale (see Tab. 1).

Table 1. Telescope Specifications

Parameters	Value/Type
Mirror aperture	0.5 m
Optics type	Richey-Chretien
Field of View	1.1 deg × 1.1 deg
Plate Scale	0.98 arcsec/pixel
Mount type	Alt-Az
Mount speed	10 deg/sec
Mount acceleration	2 deg/sec^2

The OWL Detector subsystem (DT system) is composed of a CCD camera, a filter wheel, a chopper and a time tagger (see Fig. 2). The chopper is used to cut the trail of a moving object on the image into multiple streaks. It has 4 rotating blades which intersect the light rays from the target into the CCD with a speed of 1 – 50 Hz. The time tagger is composed of a reflective sensor, and a photodiode connected via RS232 serial line to a small box which encloses a simple micro processor [2].

Figure 2. Detector Subsytem Hardware which is Composed of a CCD Camera, Filter Wheel, Chopper and Time Tagger

2 NEA OBSERVATIONS

During its close passage on 12th Oct 2017, NEA (2012 TC4) passed the Earth only 0.13 LD with a maximum reflex motion of 18 arcsec/sec; it is hard to acquire the astrometric and photometric data using the classical observation system. Owing to the OWL-Net chopper system with a maximum speed of 50 Hz, we were able to

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obtain its observational data from one of the OWL stations using dozens of tracklets.

2.1 NEA (2014 JO25)

NEA/PHA (2014 JO25) approached the Earth at a distance of 4.6 LD on 19 Apr 2017. The apparent magnitude of this asteroid was reached 10.76. We conduct the time-series photometric observations from the OWL-Net 3rd telescope in Wise observatory, Israel. The composite lightcurve of (2014 JO25) folded with the rotational periods of 4.5 hr known as Arecibo [3] and optical [4] observations was obtained in Fig 3. The amplitude of lightcurve is larger than 0.3 mag, which implies that the object is highly elongated one. This derived shape (a/b ratio) is in good agreement with the previous radar observation [3].

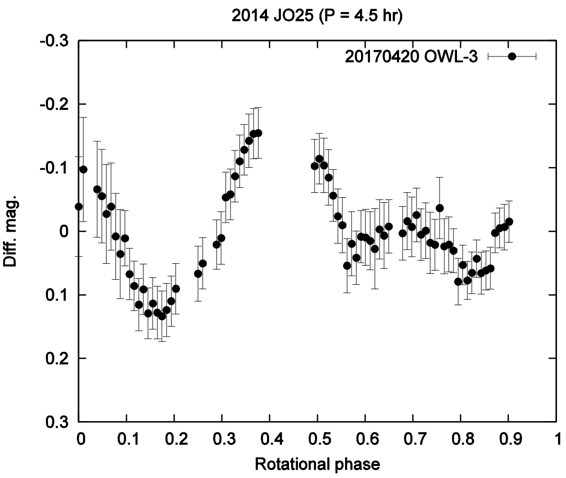

Figure 3. Composite lightcurve of (2014 JO25) folded at the period of 4.5 hr at the zero epoch of JD 2457864.27498712

2.2 NEA 3200 Phaethon (1983 TB)

NEA/PHA 3200 Phaethon (1983 TB) made a close flyby of Earth on 16 Dec 2017, and at its closest approach on that date came within 27 LD, which was the closest distance in 40 years. The observation of Phaethon was carried out The photometric observation using the OWL-Net 4th telescope in Arizona, USA was carried out on 15 to 17 Dec 2017, before and after the closest approach of Phaethon. We present the 3D shape model of Phaethon using the lightcurve inversion method [5][6] mainly based on our observations including other telescopes [7] but also with data available in the literature [8][9] (see Fig 4).

3 FUTURE WORKS

We are going to conduct further time-series observations of Earth closing approaching NEAAs to obtain 1) lightcurve data, 2) astrometric data, 3) physical properties. It could be helpful to refine the current rotational distribution of small (< 200 m) NEA population. In addition, understanding the physical properties of smaller one is crucial for preparing NEO threat and utilization.

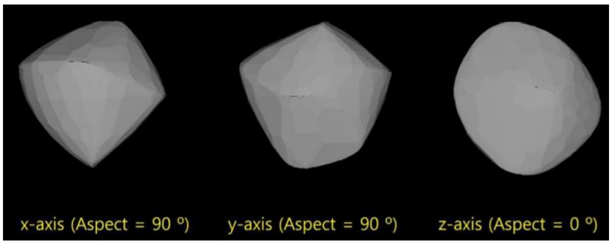

Figure 4. Three-dimensional shape model of Phaethon obtained from the lightcurve inversion method based on the unique solution with a sidereal period of 3.603957 hr and a pole orientation of (308, -52) (cited from [7])

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