Coordinated Observations of Asteroids by Pine Mountain and Nishi-Harima Astronomical Observatories

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Abstract

Coordinated broadband photometric measurements of the asteroid 665 Sabine were obtained in August 2020 from both Nishi-Harima Astronomical Observatory (NHAO) and Pine Mountain Observatory (PMO) using a 0.6 meter telescope (NHAO) and the 0.35m Robbins telescope at PMO. 665 Sabine has a rotational period of 4.294 hours, semi-major axis of 3.14 AU, and diameter of ~51km. In total, these observations produced 180 images from PMO, and 280 images from NHAO. These 460 images of the target were then analyzed to produce a "lightcurve" of the asteroid, where photometric estimates of the asteroid's brightness over time are plotted in order to extract the rotation period as well as the shape of the target. At any location, 665 Sabine cannot be tracked for more than two rotations. Continuous observation of rotating asteroids over several rotation cycles is necessary for determination of basic asteroid properties - such as the shape, surface properties, and rotation period. To obtain continuous coverage of an asteroid for more than two rotation cycles, multiple observing sites (separated by ~6 h in longitude) are needed. As a collaboration, NHAO and PMO work together to obtain data on asteroids that span several rotation periods. NHAO is operated by the University of Hyogo and located in Sayo, Japan. PMO is operated by the University of Oregon and located near Bend, Oregon.

I. Introduction

I-a. Asteroids

Asteroids are small astronomical objects orbiting the sun thought to be left-overs from the planet formation process. There are millions of asteroids in the Asteroid Belt, which exists between the orbits of Mars and Jupiter. Many asteroids are thought to be remnants of planetesimals that collided and shattered.

I-b. Coordinated Observations

One of the most important observational properties of an asteroid is the lightcurve over the entire rotation period. It allows us to derive 3-dimentional (3D) shape of the asteroids using certain algorithm.
Continuous observation of rotating asteroids over several rotation cycles is necessary for accurate determination of the lightcurve and the rotation period. However, such observations are difficult to be carried out by one observing site for majority of asteroids because they have rotation periods larger than several hours. To obtain continuous coverage for more than two rotation cycles, multiple observing sites (separated by ~6 h in longitude) are needed. Pine Mountain Observatory in Oregon and Nishi Harima Astronomical Observatory in Japan match this requirement and we work together to obtain data on asteroids that span several rotation periods.

Figure 1. Pine Mountain Observatory

II-a. Observatories

(1) Pine Mountain Observatory (PMO)

Pine Mountain Observatory, located in Central Oregon (lat ~ 44 N, long ~ 121 W), is the observing station of the University of Oregon. PMO has four domes (figure 1). The 0.36 m (14 in) Meade Schmidt-Cassegrain telescope was installed in 2015 and dubbed the "Robbins" after Kenneth C. Robins whose contributions made the project possible. [1]

(2) Nishi Harima Astronomical Observatory (NHAO)

Nishi Harima Astronomical Observatory, located in west Japan (lat ~ 35 N, long ~ 134 E), is an astronomical observatory of the University of Hyogo. Its main telescope is a 2-m telescope named "*Nayuta*". It is one of the largest-class telescopes open to public. For our project, we used 0.6 m Cassegrain telescope of the observatory. [2]

II-b. Target of the observation

Given the observing window at NHAO, We selected 665 Sabine as the target based on the observing conditions including visibility. It is an asteroid discovered on July 22, 1908, by W. Lorenz [3]. It is in the main asteroid belt and has an orbit with orbital period 5.58 years and perihelion of 2.6053 A.U. Its rotation period is 4.294 h [4].

(C) NHAO

Figure 2. Nishi Harima Astronomical Observatory

III. Observations and analysis

Although we attempted successive observations at PMO and NHAO, the observing condition did not allow continuous coverage. The observation at PMO was on August 16 and the one at NHAO was on August 24, 2020. G-filter was used at PMO, and V-filter was used at NHAO.
While the sky condition was steadily good for the PMO observation, significant portion of the NHAO observation was affected by cloudy weather. The data from PMO and NHAO were analyzed by the team at the University of Oregon using the software tools MPO Canopus[5] and APT[6]. The analysis procedure is basically the same with the one described in another poster [7] in this symposium.
The team at Kobe University analyzed the data obtained at NHAO independently using the software Makali`i [8]. Three comparison stars were selected in the field of view, and relative magnitudes of Sabine was calculated by the ratio of the brightness. Consistency was checked between the results from different comparison stars.

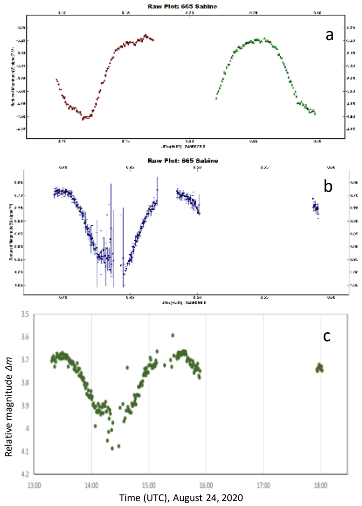

Figure 3. Light curves from observations at PMO (a) and NHAO (b and c). Data points with large error bars are the result of poor sky conditions.

IV. Results and discussion

Fig.3 shows the light curves obtained from the observations at PMO and NHAO. For NHAO, two plots are shown: Fig. 3b is the result produced by the team at the University of Oregon, and Fig. 3c is the result by the Kobe University team.
Phase matching analysis with MPO Canopus gave the rotation period of 4.294 ± 0.001 h and the modulation amplitude of 0.30 which agrees well with the known results [4] (Fig. 4). It also showed the consistency between the data from the two observatories. The 3D model of 665 Sabine reconstructed from the light curve is shown in Fig.5.

V. Conclusion

We conducted coordinated observations of an asteroid 665 Sabine at PMO and NHAO which are separated by ~6 h in longitude. Our results demonstrated such observations are effective in determining the light curves and rotation periods of asteroids that have rotation periods larger than several hours. The analysis procedure is also established, and we are planning a project to observe more asteroids and contribute to the asteroids database.

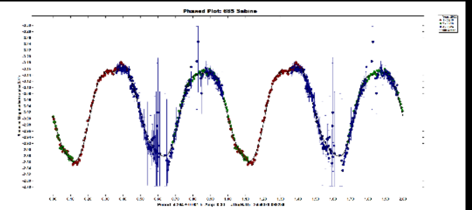

Figure 4. Phase matched light curve of 665 Sabine. 2 cycles of the period is indicated to show continuity.

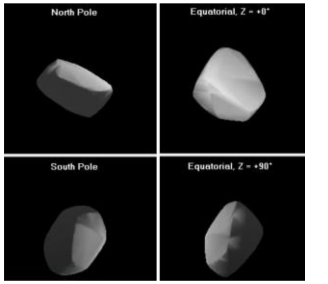

Figure 5. 3D-shape model of 665 Sabine reconstructed from the light curve.

References

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