Confirming the 3-dimensional shape of Asteroid 283 Emma from Observations at Pine Mountain Observatory

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Abstract

To determine the shape of asteroid 283 Emma, we obtained time-resolved photometry of the asteroid on August 28, 2019 from 07:44:24 to 09:27:39 UTC at Pine Mountain Observatory (PMO). The observations were carried out using the 0.35m Robbins telescope and a large format CCD camera with a Sloan g filter. The brightness of 283 Emma was calibrated using three standard stars removing the influence of airmass. We found that the brightness changed from m_g = 12.5 to 12.8. The light curve (time variation of the brightness) we obtained was consistent with the previous research which determined that the shape of 283 Emma is an ellipsoid. Through the process of data analysis, information on the atmospheric extinction coefficient in the Sloan g-band at the PMO was also obtained, which is useful for other observations at the observatory. The results of our observations give us confidence that we can obtain research-grade data with PMO and that this data can be analyzed by undergraduate students.

Figure 1

I. Pine Mountain Observatory (PMO)

Pine Mountain Observatory, located in Central Oregon, is the observing station of the University of Oregon. The site was discovered by Professor E. G. Ebbighausen in 1965. The initial telescope saw first light in 1967 and made its first research observations in summer of 1968. 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. The telescope may be operated remotely from the University of Oregon campus in Eugene. [1]

II. Target of observations

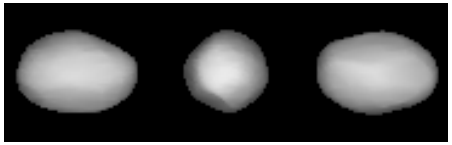
II-a. Asteroids

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.

II-b.

283 Emma is carbonaceous, C-type, asteroid [2] discovered on February 8, 1889 by A. Charlois [3]. 283 Emma is in the main asteroid belt and has an orbit with orbital period 3.353 years and perihelion of 2.59 A.U. Its rotation period is 6.896 [4]. Computer modeling of the 283 Emma is shown in figure 2 [5].

Figure 2



III. Data analysis

III-a. APT

The Aperture Photometry Tool 12.8.4 (APT) is a software package used by professional and amateur astronomers to analyze optical imaging data [6]. In this project we used APT to perform relative photometry to measure the apparent brightness of 283 Emma compared to standard stars on approximately 250 Flexible Image Transport System (FITS) images. FITS images are a data file format commonly used in astronomy.

III-b. Method of analysis

To photometrically calibrate the 283 Emma data, we also observed known standard stars HD202308, HD358303 and HD202095, choosing these standard stars on SIMBAD Astronomical Database [7] among similar magnitude in the same image frame for calibration. We performed aperture photometry using APT Model D for 120 images. First we set "24.593" as the photometric zero point for our imaging system. APT places three apertures on the sky. The smallest aperture encloses the source. The two outer apertures are chosen to be large enough so that the area between them does not include any contribution from the source. The aperture overlay for the sources in the inner red circle to be set at 5, 10 and 15 pixels. We also checked the figures using the aperture slices to confirm the objects were targeted standard stars.

IV-a. Observations and results

We observed 283 Emma on August 28, 2019 from 07:44:24 to 09:27:39 UTC. The brightness of 283 Emma was calibrated using the three standard stars removing the influence of airmass. We found that the brightness changed from m_g = 12.5 to 12.8 (figure 3). The light curve (time variation of the brightness) we obtained was consistent with the previous researches [5, 8] which determined that the shape of 283 Emma is an ellipsoid.

The ratio over the three standard stars shows that the influence of the airmass was constant (figure 4).

Figure 3

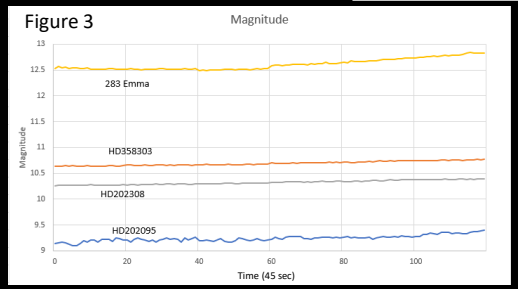
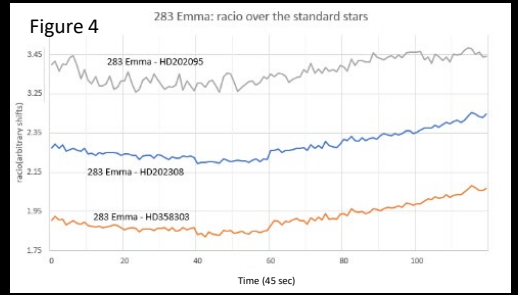


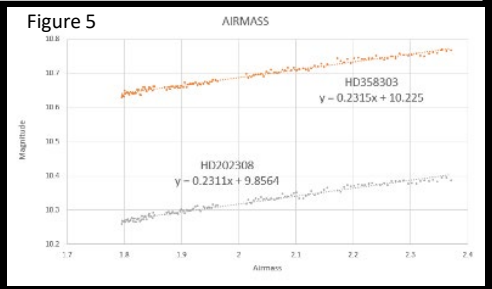
Figure 4



IV-b. Determination of atmospheric extinction coefficient

Through the process of data analysis, information on the atmospheric extinction coefficient in the Sloan g-band at the PMO was also obtained. Figure 5 shows the dependence of the observed magnitude m_g on the airmass X for the two standard stars. The data are well described by the linear relation $m_g = m_{g0} + \kappa X$. Here, m_{g0} is the magnitude of the star outside the atmosphere, and k is the extinction coefficient for the g-band at the PMO. The values of m_{g0} and κ obtained from the data for the three stars are summarized in Table 1. The g-band magnitude of HD358303 we obtained is consistent with the value, 10.20, in the SIMBAD catalogue. The values of κ we obtained are consistent with each other, and we believe that we were able to determine the extinction coefficient for g-band which is one of the essential parameters to be used to derive absolute magnitudes at the observatory.

Figure 5



Conclusion

The results of our observations give us confidence that we can obtain research-grade data with PMO and that this data can be analyzed by undergraduate students.

Figure 6

Light curve from our observations (purple) overlaid on the light curve from Stanzel (1978) [8].

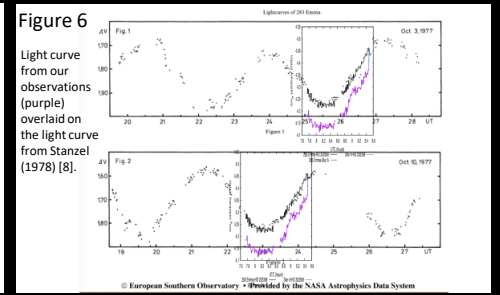


Table 1

Targets	R.A. DEC.	m_0	κ
HD202308	21h15m -11°29′	9.8564	0.2311
HD358303	21h14m -11°18′	10.225	0.2315
HD202095	21h14m -11°11′	8.6376	0.2992

References

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[8] Stanzel, R., 1978, Astronomy & Astrophysics, Suppl. 34, 373-376