

# The Rotational Period and the Surface Properties of Phaethon



Sherry Kang-Shian Pan<sup>1</sup>, Shinsuke Abe<sup>1</sup> and Daisuke Kinoshita<sup>1</sup>

<sup>1</sup> Institute of Astronomy, National Central University, 300 Zhongda Road, Zhongli, Taoyuan, 32001, Taiwan

Apollo asteroid (3200) Phaethon (1983 TB) classified as F/B-type is thought to be a dormant or an extinct cometary nuclei because (1) Phaethon has been known as the parent of the Geminids which is the most intense meteor shower of the year (e.g. Whipple, 1983) and (2) an brightening enhancement, by a factor of two, during the perihelion passage near 0.14 AU has been reported (Jewitt and Li, 2010). It was also suggested that the Apollo asteroid 155140 (2005 UD) is most likely candidate for being a slitted asteroid that generate a large member of the Phaethon-Geminid stream Complex (Ohtsuka et al. 2006). Though Phaethon is one of the most important target for the future space missions in the near Earth space to explore water and organics, the spin state and the shape is still under debate (e.g. ~3.604 hours by Meech 1996, ~5.1 kilometers in diameter by Green et al. 1985). Time-resolved visible (Johnson-Cousins BVRI) photometric observations of Phaethon were carried out using 0.81-m and 1-m telescopes at Tenagra observatory in US and Lulin observatory in Taiwan, respectively. The rotational period and the surface properties of Phaethon based on color lightcurves taken between 2011 November and 2012 February are discussed in this paper.

## Introduction

### - Apollo asteroid (3200) Phaethon

Phaethon has not displayed cometary activity (e.g., Cochran & Barker 1984; Davies et al. 1984; Chamberlin et al. 1996; Hsieh & Jewitt 2005). From a dynamical point of view, Phaethon appears to be of asteroidal origin. According to a model by Bottke et al. (2002), Phaethon has a 0% chance of coming from the Jupiter family (JF) of comets or from the Oort Cloud. In this work, we would like to make sure its rotational light curve information, the surface colors trend could show its classified type.

## Observation

### - Optical Multi-colors Photometry

We have focused on observing Phaethon from 2011 November through 2012 February with time-resolved visible (Johnson-Cousins B, V, R, I) photometric observations by 0.81-m telescope (Figure 1.) at Tenagra observatory (which typical night has 2" FWHM seeing.) in Arizona,US (110° 52' 44.8"E, +31° 27' 44.4"N, altitude 1,312m) and 1-m telescope at Lulin observatory in Taiwan (120° 52' 25" E, 23° 28' 07" N, altitude 2,862 m, seeing 1.2"~1.5"). We got around 250 data points within this project.

Since those observational data points crossed four months, the time-resolved differential photometry showed clear brightness variation and then it also was calibrated the phase angle to get the absolute magnitude. (Figure 3.)



Figure 1: 0.81-m telescope at Tenagra observatory. The pixel scale and the field of view are ~0.87"/pix and 14.8 X 14.8 arc minutes, respectively.



Figure 2: The R band image observed by Tenagra observatory for Phaethon on 29th Nov. 2011.

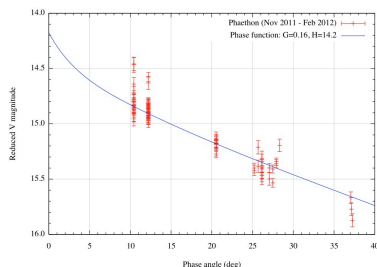


Figure 3: The variation of reduced V-magnitude against phase angle during 2011 Nov. to 2012 Feb. A phase function is fitted assuming slope parameter G=0.16.

## Analysis I

### - Rotation Period

For Phaethon, one of basic information, there are two solutions of the rotation period, 3.604 hours (Meech, K. J. et al. (1996) *ACM 1996, Abstract #42.*) and 7.208 hours (Kinoshita et al. (2012) in prep.). Employing the reduced chi-square of the lightcurve fitting, we fitted our data to the rotation period, 3.604 hours whose chi-square was closer to 1.0. (Figure 4.)

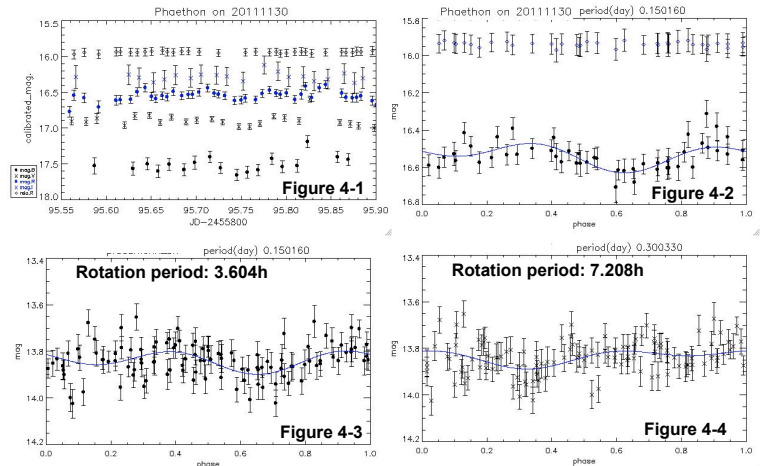


Figure 4: Phaethon was observed the four colors relative mag and compared with a stable star which was in the same FOV (Figure 4-1). The light curve fitting with rotation period 3.604h by R band (Figure 4-2). Around 250 data points was plotted by two different rotation periods which have been published before (Figure 4-3, 4).

## Analysis II

### - Color Information and Classified Type

According to the rotation period result, we assumed that the rotation period was 3.604 hours, to get the color information in our observational data (Figure 5). From color-color diagrams, we compared with NEA taxonomy data base, it showed Phaethon was comparable with F/B type asteroid. (Figure 6).

Characteristics	Pervious Work	This Work
Orbital Type	AP	
Taxonomic Type	F,B	F,B
Albedo	0.11	0.14
Diameter (km)	5.1	
H(mag)	14.345	14.177 (0.034)
G	0.16	0.16
B-V (mag)	0.59	0.62 (0.01)
V-R (mag)		0.33 (0.06)
R-I (mag)		0.29 (0.03)
Rotation Period (hrs)	3.604	3.604
Lightcurve Amplitude (mag)	0.11-0.34	0.10-0.14

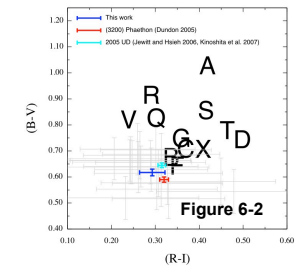
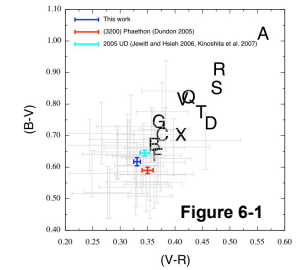
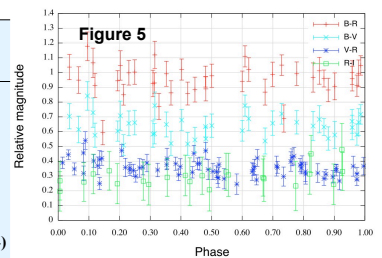


Table 1: Comparison of physical characteristics of Phaethon (Near Earth Objects Dynamic Site) and This study.

Figure 5: Those were color information which were plotted with a phase.

Figure 6-1,2: Two color diagrams comparing with typical values of NEAs (Dandy et al. 2003) showing Phaethon belonging to a F/B type asteroid.