Measuring the Light Curve and Rotation of Asteroid 16 Psyche

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April 2022

Contents

1 Introduction

The purpose of this report is to measure the light curve of the asteroid Psyche-16, and using the information to determine it's orbital period. The light curve is the variation of an object's magnitude over time, which will give information the asteroid's orbital position in space.

16 Psyche is a metal-rich asteroid, about 226 km in diameter and orbits about 2.5-3.3 AU from the Sun, between Mars and Jupiter. It takes about 5 years for it to complete one orbit around the Sun [2]. It was thought to have been a shattered fragment of a planet due to it's metal rich nature, however more recent studies have concluded that the asteroid might not be be as rich in minerals as previously predicted [1]. NASA has currently planned a mission to 16 Psyche, with the goal of studying its origins in more detail. The Psyche spacecraft is planned to arrive in early 2026 [3].

The light curve in this report will be analysed using the astronomical image processing software IRIS. It can be used to determine the asteroid's period or rotation around it's axis. As the phase angle changes over time, the illumination of the asteroid from the earth will be periodic, giving insight into its rotation.

2 Telescope specifications

The data was gathered using through the iTelescope network. A summary of the telescope specifications are given in Table 1.

Telescope	Telescope 11
Location	Mayhill, New Mexico
Timezone	Mountain Daylight saving time (UTC-7hr)
Date	2/19/2022
Start Time	23:00
End Time	3:00
Observatory code	H06
Telescope type	Deep sky
Weather	Clear
Pixel size	9μm square
Focal length	2280 mm
Resolution	0.81 arc-secs/pixel
Aperture	510 mm
F/fline	f/4.5
Filter	V

Table 1: Telescope and observing data

The data was collected over 4 hours, over intervals of 60 seconds for each image, giving a total of 240 images.

3 Results and Analysis

The images were analysed using the astronomical image processing software IRIS. To determine the location of 16 Psyche, The first and last images of the data were compared. Among a background of fixed stars, the object that moved the most was determined to be 16 Psyche.

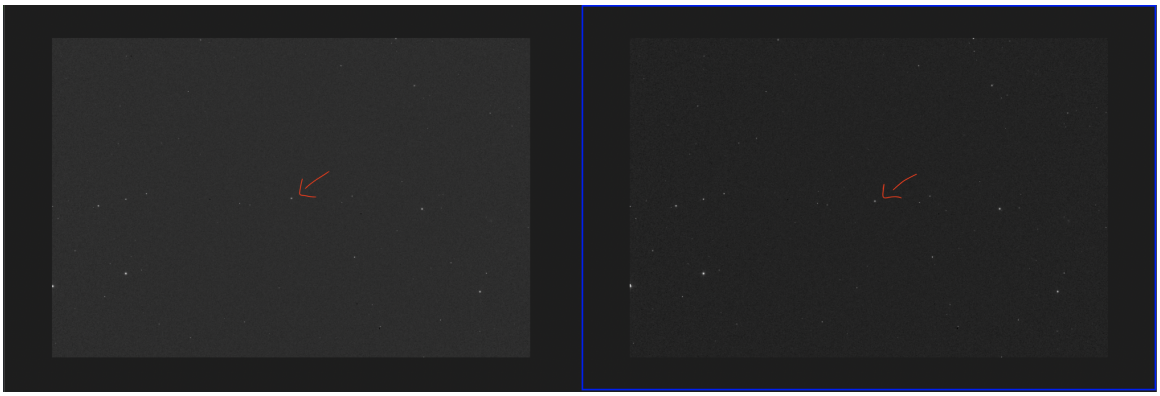

Figure 1: A comparison of the location of 16 Psyche over the span of a few hours.

After determining the location of 16 Psyche, the series of images were analysed using IRIS to determine it's light curve. The iTelescope network calibrates the images using bias, dark and flat frames to optimize the signal-to-noise ratio of the images. The threshold of the sequence of images was optimized to see the asteroid and other stars for a magnitude reference. Upon analysis, the images were aligned and two background stars were selected (Fig 2) and their magnitude is assumed to be fixed in comparison to 16 Psyche.

The velocity in pixels/Julian day was determined over the period. Over a range of 24 images, the data in Table 2 was used to determine the velocities and magnitude of the asteroid:

x_1	2931.453
x_2	2909.998
y_1	1812.303
y_2	1810.676
Julian day1	2459630.8989
Julian day 2	2459630.925

Table 2: Data from images used to determine velocities and magnitude of 16 Psyche

The velocity in the x direction is

$$\begin{aligned} v_x &= \frac{21.455}{0.0264} \\ &= 812.6894 \text{ px/Julian day} \end{aligned}$$

And the velocity in the y direction is

$$\begin{aligned} v_y &= \frac{10.627}{0.0264} \\ &= 402.5379 \text{ px/Julian day} \end{aligned}$$

Using two stars as a reference (Fig. 2), the mean magnitude is 2.3399 with a standard deviation of 0.1498, giving an accuracy of 94%. Some errors could be due to weather conditions during imaging and light gradients from the Moon or other bright light sources.

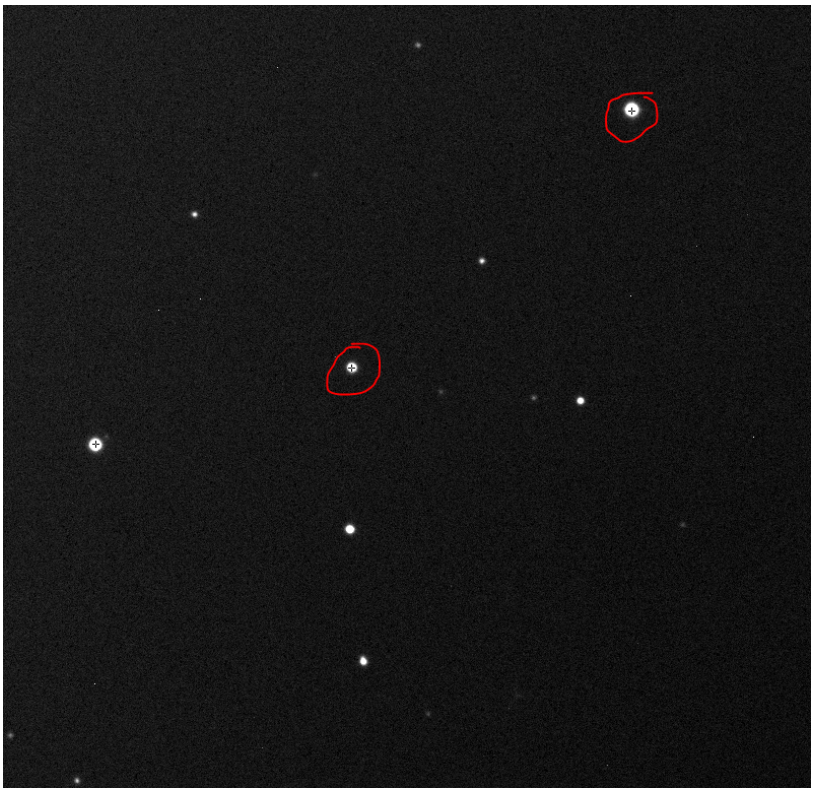

Figure 2: Reference stars used to determine magnitude

Fig. 3 shows the period analysed using the Time Series Analysis Tool from IRSA, where the period is 0.1699 Julian day, or, 4.07 hours.

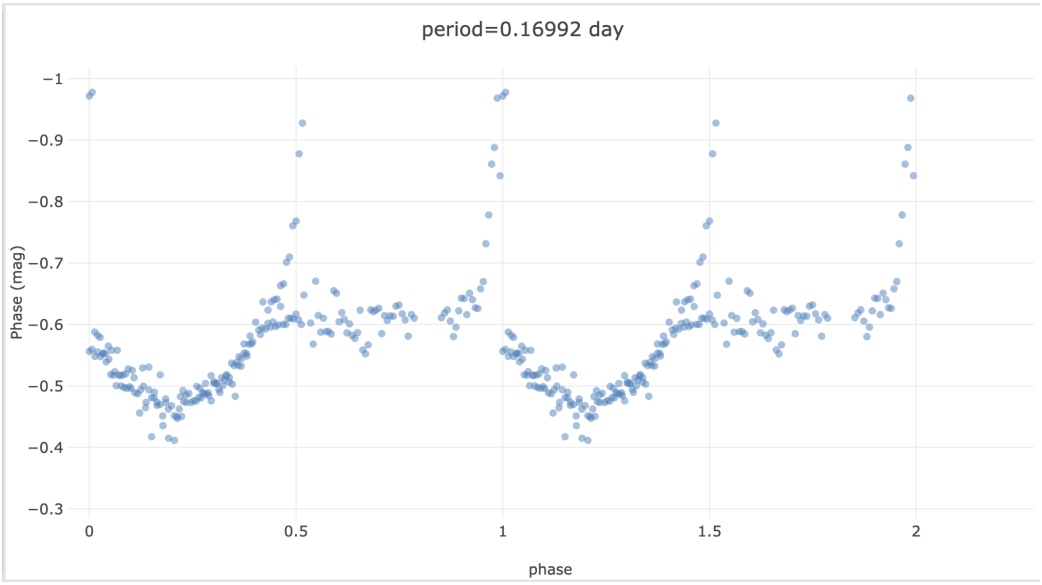

Figure 3: Period of 16 Psyche in Julian days, determined using the Time series tool by IRSA

The data was fit to a phase period of 0.91 (Fig. 4), which aligns with the "Grand Total Light Curve" (Fig. 5), analysed using a combination of data from the whole class.

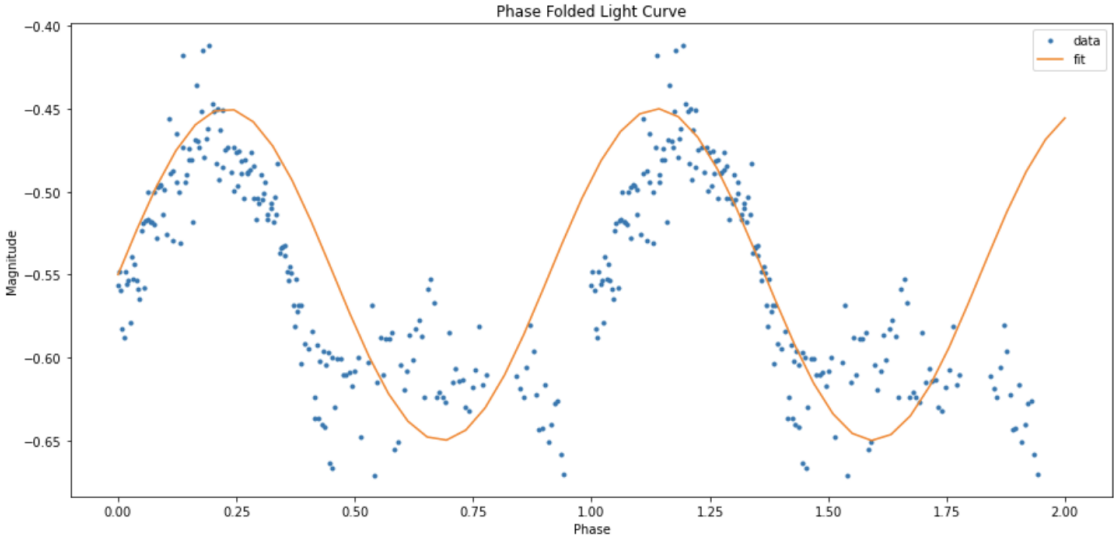

Figure 4: Fitting for the period of the light curve.

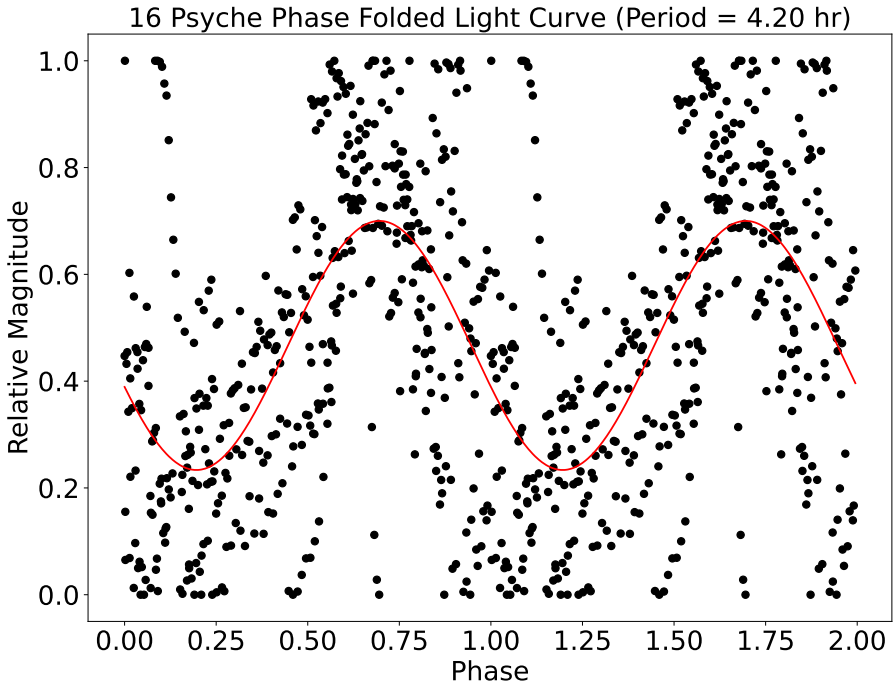

Figure 5: Light curve determined by the results of the entire class.

4 Conclusion

Upon careful analysis of the images obtained by the iTelescope network, the light curve of 16 Psyche was obtained, allowing for calculations of the asteroid's speed, magnitude and rotational period to a high degree of accuracy. The rotation period is thus determined to be approximately 4.07 hours, which aligns with the total light curve from the overall results of the class(Fig. 5), as well as the results from NASA, where the period of rotation is 4.196 hrs [2].

References

[1] Elkins-Tanton, L. T., Asphaug, E., Bell, J. F., Bercovici, H., Bills, B., Binzel, R., Bottke, W. F., Dibb, S., Lawrence, D. J., Marchi, S., McCoy, T. J., Oran, R., Park, R. S., Peplowski, P. N., Polanskey, C. A., Prettyman, T. H., Russell, C. T., Schaefer, L., Weiss, B. P., ... Zuber, M. T. (2020). Observations, meteorites, and models: A preflight assessment of the composition and formation of (16) psyche. Journal of Geophysical Research: Planets, 125(3). https://doi.org/10.1029/2019je006296.

[2] NASA. (2021, December 2). *Asteroid Psyche*. NASA. https://solarsystem.nasa.gov/asteroids-comets-and-meteors/asteroids/16-psyche/in-depth/

[3] Greicius, T. (2017, May 11). *Psyche overview*. NASA. Retrieved April 8, 2022, from https://www.nasa.gov/mission_pages/psyche/overview/index.html

[4] Caltech. (n.d.). *NASA/IPAC Infrared Science Archive*. IRSA. Retrieved April 8, 2022, from https://irsa.ipac.caltech.edu/