Characterization of Asteroid 93 Minerva Searching for Variation of the Light Curve to Determine Physical Attributes

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Abstract

In 1967 Pine Mountain Observatory (PMO) made its first observations of astronomical objects that included everything from nearby planets and asteroids to distant nebulae and galaxies. In 2018, PMO continues to make such observations of various kinds of celestial targets. In this poster we present the results of broad-band optical photometry of the asteroid 93 Minerva obtained using the 0.36 m Robbins telescope on September 5, 2018 (UTC). On this night the target asteroid was continuously observed for roughly 2.5 hours to measure variations in its light curve. The shape and magnitude of the changes in the light curve can be used to determine physical characteristics of 93 Minerva including rotation period and three-dimensional shape. Photometry of 93 Minerva, as well as calibration stars, was performed using the Aperture Photometry Tool (APT) developed by E. G. Schommer. Although there were non-optimal observing conditions, our obtained light curve closely matches previously published 93 Minerva data. The data are a successful proof-of-concept of our ability to perform accurate photometry of moderately faint objects at PMO. With this successful test, we will soon start an asteroid monitoring program at PMO. In conjunction with our colleagues at Kobe University in Japan, we will collect multiple, short-cadence photometry on several asteroids to construct light curves and map their three-dimensional features.

II. 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. Although the majority of asteroids are located in the main belt, there are also near-earth objects (NEO’s) whose orbits bring them close to the Earth. There are over 10,000 NEO’s but only a fraction of these are currently near Earth. As we move further out in the Solar System, we find the trans-Neptunian objects and then the Kuiper Belt objects. The Kuiper belt located from Neptune (30 AU) to about 50 AU in figure 4.2

93 Minerva is a carbonaceous, C-type asteroid discovered on August 24, 1867 by C. J. Watson. 93 Minerva is in the main asteroid belt located between the orbits of Mars and Jupiter (figure 5 and 6) [9, 10]. 93 Minerva has an eccentric orbit with orbital period 4.58 years and perihelion of 2.37 A.U. [9]. Minerva is 17.1 km in radius and nearly spherical in shape. Computer modeling of the 93 Minerva is shown in figure 7 [3].

III. Aperture Photometry Tool

The Aperture Photometry Tool (APT) is a software package used by professional and amateur astronomers to analyze optical imaging data. In this project we used APT to perform relative photometry (that is, to measure the apparent brightness of 93 Minerva against a standard star) on approximately 250 Flexible Image Transport System (FITS) images. FITS images are a data file format commonly used in astronomy. To photometrically calibrate our 93 Minerva data, we also observed known standard stars TYC12-1091-1 and TYC12-1091-2 in the same night. 93 Minerva's light curve was computed using light curve inversion (figure 13). When TYC14-784-2 was subtracted from the light curve, we observed a magnitude of 0.035 magnitudes in the final 45 minutes. This closely resembles the published light curve of 93 Minerva in figure 15 [5]. From the calculations and uncertainty, we have concluded it is very likely we obtained a portion of Minerva's light curve.

Data Analysis and Results

We observed 93 Minerva on September 5, 2018 from 00:45:18 to 00:45:32 UTC. Here UTC stands for Coordinated Universal Time. The night we observed 93 Minerva, there was smoke from local forest fires which affected our data. We can see that all the observed stars in the field were affected by the smoke due to the fact that even our standard star showed similar downward slope (see figure 12). We correct for the non-optimal observing conditions by subtracting TYC 14-784-1 from 93 Minerva (figure 13). When TYC 14-784-1 was subtracted from comparison Star 1, the residuals were flat with scatter of about 0.01 magnitude (figure 14). This suggests our uncertainty was on the order of 0.01 magnitudes. We see that 93 Minerva was initially constant in brightness, falling by 0.035 magnitudes in the final 45 minutes. This closely resembles the published light curve of 93 Minerva in figure 15 [5]. From the calculations and uncertainty, we have concluded it is very likely we obtained a portion of Minerva's light curve.

In June 2019 we will restart our observing campaign of 93 Minerva with the goal of obtaining > 10 hours of light curve data to ensure we measure one complete rotation of the target. Our 93 Minerva observations will be part of a larger asteroid monitoring program where our goal is to obtain high quality light curves for roughly 12 asteroids over summer 2019.

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