EPSC Abstracts
Vol. 13, EPSC-DPS2019-318-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Asteroid Photometry from the Transiting Exoplanet Survey Satellite

Andrew McNeill (1), Michael Mommert (2), David E. Trilling (1), Colin O. Chandler (1) and Joseph Llama (2)
(1) Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011, USA (2) Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ, 86001, USA

Abstract

We present photometric measurements for main belt asteroids (MBAs) measured by the Transiting Exoplanet Survey Satellite (TESS). TESS data provides a unique opportunity to measure the lightcurves of thousands of asteroids continuously for twenty-seven days. This large-area survey allows us unbiased sensitivity to rotation periods from hours to many days. This is the first data set to allow a probe of long asteroid rotation periods. We present a sample of the 300 constrained rotation periods and 6600 partial light curves obtained from Sectors 1+2 of the TESS Public Data Release.

1. Introduction

The primary mission of the Transiting Exoplanet Survey Satellite (TESS) is the search for exoplanets orbiting bright and local stars [1]. The satellite is on a highly elliptical orbit around the Earth in 2:1 resonance with the Moon. During its first year TESS will observe the entire southern sky in 13 unique sectors, with each pointing observed for 27 days, and will do the same for the northern sky in Year 2. This is shown in Figure 1 [2]. TESS observes with four wide-field optical cameras (each consisting of four 2k×2k CCDs) with a total field of view for each sector of 24×90 degrees. Brightness measurements for point sources are made every two minutes and stacked into images covering 30 minutes. The magnitude range of the cameras corresponds approximately to $8 < V < 17$, with 21 arcsecond pixels.

We have carried out a pilot study based on a small sample of the initial TESS public data release. The data used in this study is from Camera 1 (the camera closest to the ecliptic) while the satellite was in its first two pointings (i.e. Sectors 1 and 2). In this subset we find a total of 6600 unique asteroids. Filtering the data to include only asteroids with >100 detections we obtain rotation periods for 300 objects.

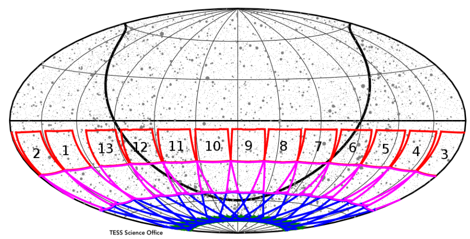

Figure 1: A diagram in ecliptic coordinates showing the pointings for the first year of the TESS mission. Each camera is outlined in a different colour and consists of four CCDs. The primary camera used in this work will be Camera 1, outlined in red. The thin black line is the ecliptic, the thick black line is the galactic plane. In the second year of operations TESS will observe the Northern Hemisphere.

Of these, 20 have previously measured rotation periods in the Lightcurve Database (LCDB, [3]) from sparse data. In each case our derived rotation period agrees with the existing period within the tolerance for quality code U = 2-. As our light curves will show multiple rotations and are not constructed from sparse data we consider our rotation periods and improvement over the existing values. Over the nominal two-year lifetime of the mission, therefore, we expect to detect around 48,000 unique asteroids in our data set and obtain rotation periods for around 4000 of these. If the mission is extended we expect that this yearly production rate would continue.

2. Results

Here we present an example of (1193) Africa, an object in our pilot study which already has a period estimate in the LCDB. This object has a derived rotation period from sparse photometry $P = 157.8 \pm 0.2$ h and has an assigned quality code $U = 2+$. Using

Gaussian processing, we have identified and removed outlying data points from consideration. From this processed data we are able to identify a strong signal in the periodogram in the data with a peak corresponding to $P = 157.35 \pm 0.40$ h, and with a false alarm probability of order 10^{-8}. The folded light curve to this rotation period is presented as Figure 2.

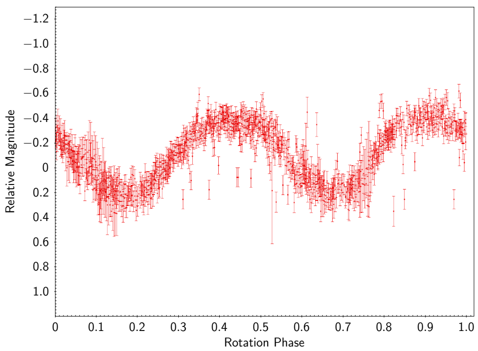

Figure 2: The light curve for the same object folded to the best fit rotation period, $P = 157.35 \pm 0.40$ h

In the pilot study we find that 10% of our targets have periods longer than 100 hours, so we estimate that we will derive periods for 600 slow rotators during the mission lifetime. For main belt asteroids in our magnitude range there are currently 517 objects with a determined period in this range with only 42 of these considered to have unambiguous period solutions. Thus, our result will be to increase the number of asteroids with well-known long periods by more than an order of magnitude.

The shape distribution for populations of asteroids has been determined using several sky surveys and data resources [4] [5]. To date, shape distribution studies of asteroids have had to make assumptions about the abundance and shapes of slow rotating asteroids due to the lack of objects for which rotational information is available. This work will identify many slow rotators and constrain accurate rotation periods and obtain lower-limit elongation estimates for these bodies. This will give a clearer picture of the abundance of these objects which will allow for more reliable shape distribution models to be obtained. As part of this project we will obtain the shape distribution of slow rotating asteroids and compare and contrast this with existing shape distribution models for main belt asteroids. We will present a shape distribution from the TESS data accounting for these slow rotators and utilising all of the photometry obtained during this project including sparse or fragmentary light curves. Additionally, this work will allow us to estimate the proportion of objects with slow rotation periods so that this can be more correctly accounted for in future studies of asteroid shape distributions.

3. Summary and Conclusions

We present photometric light curves obtained from the Transiting Exoplanet Survey Satellite. In the magnitude range of TESS we are sensitive to rotation periods in the approximate range $3 < P < 700$ h. In this initial pilot study we have obtained sparse or fragmentary photometry for 6600 main belt asteroids and constrained the rotation period for 300 of these. Over the nominal two-year mission lifetime of TESS we expect to detect around 48,000 unique asteroids in our data set and obtain rotation periods for around 4000 of these.

Acknowledgements

This work includes data collected by the TESS mission. Funding for the TESS mission is provided by the NASA Explorer Program. This work made use of sbpy (http://sbpy.org), a community-driven Python package for small-body planetary astronomy supported by NASA PDART Grant No. 80NSSC18K0987.

References

[1] Ricker, George R.; Winn, Joshua N.; Vanderspek, Roland et al.: Proceedings of the SPIE, Volume 9143, id. 914320 15 pp., 2014

[2] TESS Science Office - https://tess.mit.edu/observations/

[3] Warner, Brian D.; Harris, Alan W.; Pravec, Petr: Icarus, Volume 202, Issue 1, p. 134-146, 2009.

[4] Cibulková, H.; Nortunen, H.; Ďurech, J. et al.: Astronomy Astrophysics, Volume 611, id.A86, 10 pp, 2018

[5] McNeill, A.; Hora, J. L.; Gustafsson, A. et al.: The Astronomical Journal, Volume 157, Issue 4, article id. 164, 6 pp. 2019