LIGHTCURVE BASED DETERMINATION OF 10 HYGIEA'S ROTATIONAL PERIOD WITH TRAPPIST-NORTH AND -SOUTH

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A densely-sampled lightcurve of the large main-belt asteroid 10 Hygiea was obtained with the TRAPPIST-South (TS) and TRAPPIST-North (TN) telescopes in 2018 September and October. We found its synodic rotation period and amplitude to be 13.8224 ± 0.0005 h and 0.27 mag. The data have been submitted to the ALCDEF database.

Observations of the large main-belt asteroid (MBA) 10 Hygiea were acquired with the robotic telescopes TRAPPIST-North (TN, Z53) and TRAPPIST-South (TS, I40) of the Liège University (Jehin et al., 2011). They are located, respectively, at the Oukaïmeden Observatory in Morocco and the ESO La Silla Observatory in Chile. Both are 0.6-m Ritchey-Chrétien telescopes operating at *f*/8 on German Equatorial mounts. TN camera is an Andor IKONL BEX2 DD (0.60 arcsec/pixel) and the one of TS is a FLI ProLine 3041-BB (0.64 arcsec/pixel).

The raw images were calibrated with corresponding flat fields, bias and dark frames and photometric measurements were obtained using *IRAF* (Tody, 1986) scripts. The differential photometry and lightcurves were made with Python scripts. For the differential photometry, all the stars with a high enough SNR were used and checked to discard the variable stars. Various apertures were tested to maximize the SNR. In the composite lightcurve below, the normalized relative flux is plotted against the rotational phase. The rotation period was determined with the software *Peranso* (Vanmunster, 2018), which implements the FALC algorithm (Harris et al., 1989). The reported amplitude is from the Fourier model curve.

10 Hygiea is the fourth largest MBA with a diameter of 434 ± 14 km (Vernazza et al., 2019). Since 1991, all of Hygiea's reported rotation periods agreed with a value close to 27.6 h (LCBD, Warner et al., 2009) but were each time built from sparsely sampled lightcurves. In support of the ESO Large Programme 199.C-0074 (Vernazza et al., 2018) aiming to determine precise volumes and densities of the 40 largest MBAs, we started extensive photometric observations of Hygiea to refine its rotation period and help in the shape and spin axis determination. Such a long period is challenging to cover, especially when it is close to 24 h (the 27.6 h period translates in a phase shift of only 13% of the rotation each night), explaining the lack of dense lightcurves for this large and bright asteroid. To tackle this challenge, the complementarity of the two TRAPPIST telescopes at two different longitudes was decisive to acquire long and continuous photometric series as illustrated in Ferrais et al. (2020).

We observed Hygiea in 2018 from September 10 to October 17 with TN and TS using the Johnson-Cousins broad band Rc filter, no binning, and an exposure time of 8 seconds. As more data were gathered, the phased lightcurve started to show a classic double-sinusoidal shape with the previously reported period but with the high quality of the data, we noticed it was perfectly symmetric (see Fig. 1 for the final lightcurve phased with P = 27.6 h). Therefore, we produced the split halves plot which showed two identical halves and a very convincing fit (Fig. 2). From the final data set rich of 9490 images split in 13 long photometric series for a total of 73 h, a new synodic period of 13.8224 ± 0.0005 h was derived and confirmed by the converging 3D model built with the VLT/SPHERE adaptive optics images (Vernazza et al., 2019). These images revealed the spherical shape of Hygiea and albedo features at its surface, explaining the single-peak shape of its lightcurve.

Following the publication of the new period in Vernazza et al. (2019), Pilcher (2020) derived a similar synodic period of 13.828 ± 0.001 h from photometric observations obtained in 2019. We stress with this example the importance of high-quality photometric data to derive asteroid rotation periods, especially for those having a period close to a multiple of a day and to be careful with symmetric double-peak lightcurves which might have in reality half the period due to an albedo feature rather than due to their shape.

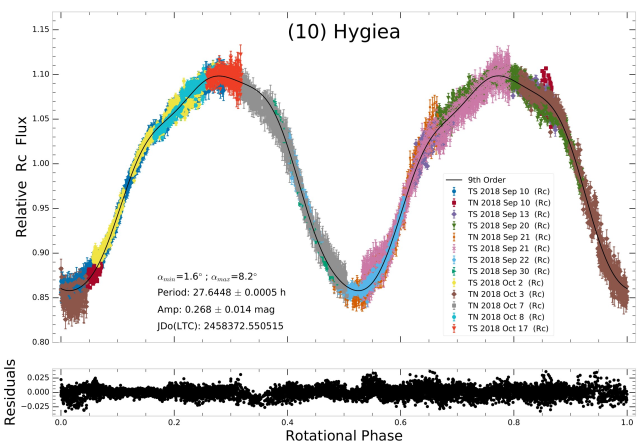

Figure 1. Phased lightcurve using the previously reported rotation period of 27.6 h.

Number	Name	2018 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
10	Hygiea	09/10-11/17	9490	*4.8,8.2	0.6	4.6	13.8224	0.0005	0.27	0.01	MB-O

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date and reached a minimum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner *et al.*, 2009).

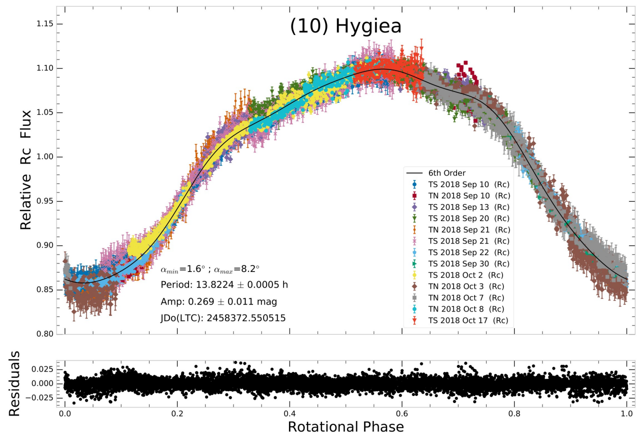

Figure 2. The lightcurve phased using the new period of 13.8224 h.

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