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Research Note

The rotation period of 804 Hispania: Some considerations on its nature

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Abstract. Photometric observations of 804 Hispania performed at the Teide Observatory during the opposition in September 1998 are presented and analyzed. A rotation period of 7.405 ± 0.010 h was derived. It was possible to confirm that the lightcurve presents two maxima and minima. We discuss in detail some considerations on its nature.

Key words. micro planets, asteroids – solar system: general

1. Introduction

The asteroid 804 Hispania was observed during its opposition in September 1998 when its magnitude was $V = 10.8$. This is a C type asteroid, which is a very common type with a 161 Km diameter (Tedesco 1989) Photoelectric measurements to obtain the light curve and rotation period have been reported by several authors (Harris 1983; Debehogne 1983; Magnusson et al. 1991); however, the period value has not been unambiguously determined; at least two values have been proposed (14.851 h and 7.42 h) We aimed to determine the period and to confirm the presence of a secondary minimum in the light curve.

2. Observations

Observations were performed during 5 nights at the Observatorio del Teide (Canary Islands-Spain) using the MONS telescope, a 0.5 m diameter Cassegrain equipped with a photoelectric photometer. The photomultiplier tube was a Hamamatsu 1P21-P, a very low dark current device (final test sheet from Hamamatsu gives a 0.07 nA dark current at a temperature of 25 °C). V and B band data were reduced in the standard way. Expected data for the observed asteroid are given in Table 1, where the heliocentric and geocentric distance r and Δ are measured in astronomical units and α is the Solar phase angle. Comparison stars' data are reported in Table 2 (from the Tycho catalogue).

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Table 1. 804 Hispania expected data

DATE 0^{h}UT	RA_{2000}	DEC_{2000}	Δ	r	α
1998 Sep. 18	23:08:12.377	−04:36:09.57	1.454	2.452	3.53
1998 Sep. 19	23:07:12.412	−04:34:35.55	1.457	2.453	4.02
1998 Sep. 20	23:06:13.108	−04:32:50.68	1.460	2.453	4.50
1998 Sep. 21	23:05:14.538	−04:31:21.75	1.463	2.454	4.98
1998 Sep. 22	23:04:16.770	−04:29:41.60	1.467	2.454	5.46
1998 Sep. 23	23:03:19.873	−04:27:59.03	1.471	2.455	5.93

Table 2. Comparison stars' data

Object	RA_{2000}	Dec_{2000}	V	$B-V$	Type
SAO 146467	23:02:37.641	−03:59:24.98	9.83	1.472	K2
SAO 146448	23:01:23.211	−04:22:21.93	9.57	0.378	F8

3. Analysis

The light curve in the V band was obtained after reducing the data in the classical way: the apparent magnitude was first corrected for distance and related to H, the magnitude at zero phase angle by:

$$H(\alpha) = H - 2.5 \log((1-G)\Phi_1(\alpha) + G\Phi_2(\alpha)), \qquad (1)$$

here G is the slope parameter which gives an indication of the gradient of the phase curve and Φ_1, Φ_2 are two specified phase functions derived empirically (Bowell et al. 1989). In our case we assumed $G = 0.09 \pm 0.02$ (given by Harris & Young 1983); the accuracy of measurement is ± 0.02 magnitude in V band.

Table 3. Frequencies identification

	Frequency	Identification	Θ_{ob}	p value
a	3.241	f_0	0.25	0.00
b	2.184	$2/3\ f_0$	0.35	0.00
c	1.625	$f_0/2$	0.51	0.00

4. Results

The period was detected using the Phase Dispersion Minimization technique (Stellingwerf 1978), which is particularly suitable in cases where only a few observations are available during a short time and with a non-sinusoidal light curve. This method tries to minimize the Θ statistic, which is a measure of the dispersion of observed data round a mean light curve related to a trial frequency. We used the Algol software package, developed by members of GEOS (P. Bernasconi and A Gaspani). The main frequency was first determined by a rapid scan and subsequently verified with further testing of accuracy.

The PDM technique finds all the periodic components; the master frequency normally corresponds to a minimum value of Θ at the regions in the periodogram where the subharmonics also appear ($f_n = f_0\ /\ n$, where f_0 is the principal frequency and n is an integer >1); aliased frequencies appear as harmonics of frequency $f \pm 1$, $f \pm 1/2$, $f \pm 1/3, ..., \ 2f \pm 1, \ 2f \pm 1/2$.

To determine the statistical significance of the periods derived using phase -dispersion -minimization, we apply the randomization test proposed by Nemec & Nemec (1985) to verify the null hypothesis that the period is equal to a determinate value. The software is in the Matlab package and was adapted by the authors using some scripts by Dr. Eran O. Ofek.

The $\Theta_{ob}(P_0)$, corresponding to the trial period P_0 evaluated for the observed data, was compared to the $\Theta(P_0)$ of random ordered data, with the hypothesis that if there is no periodicity in the observed data, the magnitude is independent of observation time.

The p value is the proportion of permutations that give a value of $\Theta(P_0)$ less than or equal to $\Theta_{ob}(P_0)$. If the null hypothesis is true, the difference between $\Theta(P_0)$ and $\Theta_{ob}(P_0)$ is negligible and p is not small; on the other hand, if a periodic structure is present, the difference between $\Theta(P_0)$ and $\Theta_{ob}(P_0)$ is relevant and p is negligible.

In our test we used $m = 5000$ random permutation; in Table 3 we identify the frequency corresponding to a relevant peak of Θ_{ob}. As a final test to eliminate spurious value, we searched for frequencies with a p value <0.01 (95% confidence interval 0.0 to 0.01 using a binomial distribution). Only the main frequency gave us a rotational phase curve; using other frequencies we obtained a random distribution of the observed data.

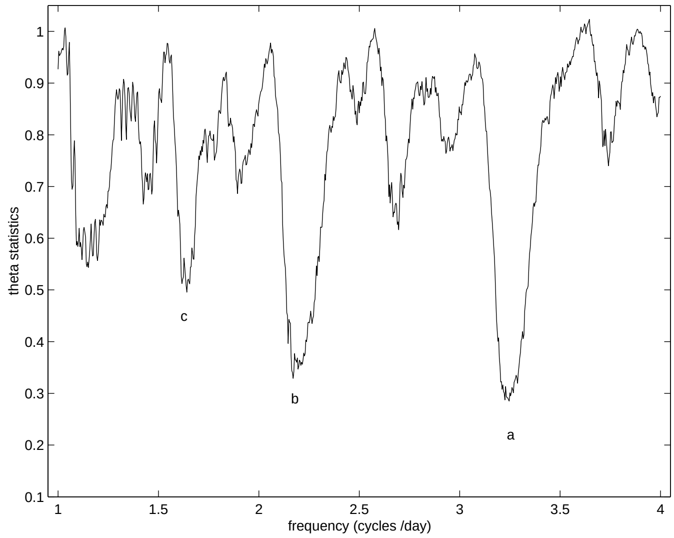

Fig. 1. Periodogram

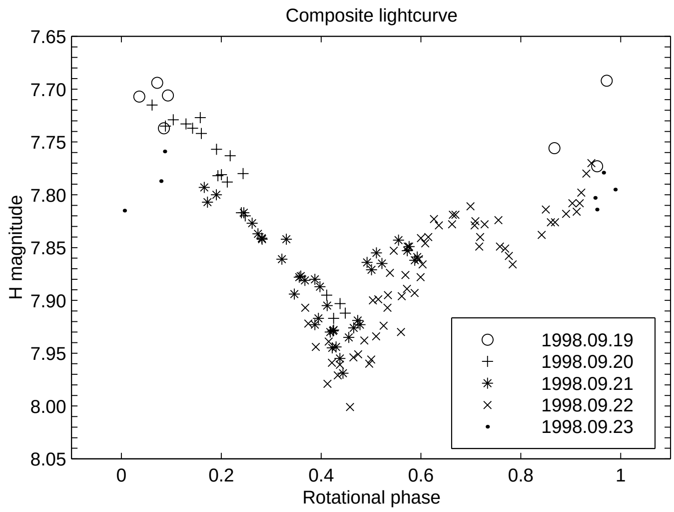

Fig. 2. Composite lightcurve with zero phase at UT 1998 September 20

The main frequency value was estimated at 3.241 ± 0.005 cycles per day corresponding to a synodic period of 7.405 ± 0.010 h, in accordance with Debehogne et al. (1983) who found 7.42 h. This value is also close to the half period found by Harris & Young (1983).

In Fig. 1 we show the Θ transform versus frequency in cycles per day ($f_{min} = 1$, $f_{max} = 4$; resolution $\Delta f = 0.0035$).

In Fig. 2 we report the composite lightcurve corresponding to a 7.405 ± 0.010 h period and confirm that the lightcurve shows two maxima and two minima.

Debehogne et al. (1983) discuss this light curve and report two distinct hypotheses: a particular parallelepiped like asteroid shape or a binary nature.

Applying the procedure proposed by Leone et al. (1984) it is possible to obtain a binary model from the observational parameter spin period and light curve amplitude.

We performed the analysis using the network of Roche sequences in the plane $A - \omega$, the rotational parameter $T = 7.405$ ($T = \frac{2\pi}{\omega}$ in hours) and $A = 0.2$ ($A =$ lightcurve amplitude of the system). Our results show that the model used may be consistent with a binary system whose mass ratio between the two components is $q = 0.1$ and a density $3 \leq \rho \leq 5$ g cm^{-3} (ρ density assumed to be equal for both components).

A density of 3 g cm^{-3} is the upper limit for a C type asteroid so we could not rule out the binary nature of 804 even if the probability is low.

5. Conclusions

We detected synodic period of 7.405 h for the asteroid 804 Hispania. In addition, we found the value of $H = 7.90$ to be in agreement with the IRAS observation $H = 7.87$ and a $B - V = 0.73 \pm 0.05$. We note that there is some possibility that the asteroid may be a double body with a mass ratio of 0.1. We are aware that a definitive solution to this problem will only be found by different observation techniques, such as occultations or speckle interferometry.

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