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Investigating V-type asteroids outside Vesta family

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Abstract

We are conducting a photometric, spectroscopic, and dynamical study of V-type asteroids outside the Vesta family in the inner main belt. The aim is to find traces of once existing differentiated planetesimals other than Vesta, to provide the missing observational evidence for theories predicting an abundance of such planetesimals in the early solar system.

1. Introduction

Most V-type asteroids are compositionally and dynamically linked to asteroid (4) Vesta. Additionally, most of the HED meteorites have a well established link to this parent body. However, there is a growing number of other V-type asteroids that show different spectral and dynamical properties, and might be parent bodies of isotopically anomalous HED meteorites (non-Vestoids, [5], [2]). They add evidence to theoretical studies which predict that a large number of differentiated planetesimals existed in the early solar system, which later have undergone collisional disruptions, leaving debris asteroids whose typical composition comprises a basaltic crust, an olivine mantle and an iron core.

One possible way to study the origin of non-Vestoids in the inner main belt is to determine their sense of rotation. Then, using this information together with their orbital and physical parameters, it is possible to trace their dynamical evolution through the Yarkovsky drift (inwards or outwards the center of the solar system [8]), which depends on whether the body rotates in retrograde or prograde sense, respectively. Also, from the dilution of periods within a collisional family one can establish the family formation age.

We are conducting a consolidated study joining photometry, spectroscopy and dynamical simulations to trace back the orbital evolution of ∼20 non-Vestoid V - type asteroids and search for evidence of their origin, which, if not Vesta, must be some other compositionally differentiated parent body.

2. Photometric campaign

Since the year 2015 we have been conducting an intensive photometric campaign of selected V-types primarily to determine their sense of rotation using the epoch method [1] or, when multi-apparition data are gathered, spin and shape modelling via the lightcurve inversion method [3]. So far we have successfully determined senses of rotation of a few bodies of our sample [7], but for more statistically meaningful results we continue the campaign for more targets. We also perform spectroscopic observations to verify their spectral type and analyse their dynamical history, taking into account the sign of the Yarkovsky drift. Our focus is on Cell I and Cell II V-types defined by [6], where we aim to find distributions of spins that would clearly show if they all originated from Vesta, or have come from some other parent body.

3. Results

Our campaign, due to the small sizes of the studied targets (4-10 km in diameter) is conducted with telescopes with mirror diameters from 0.6-m to 2.2-m. So far we have determined synodic rotation periods for 17 targets (Tab. 3), in some cases over multiple apparitions, and we are on a good way to determine their spins and shapes. In most cases the periods that we found agree with those published in the Lightcurve Database (LCDB, [9]), however in one case we found

Asteroid name	Diameter (JPL) [km]	Rotation period (LCDB) [h]	Rotation period in first apparition (this work) [h]
(1914) Hartbeespoortdam	9.561 ± 0.186	6.331	6.3404 ± 0.0002
(2247) Hiroshima	4.367 ± 0.098	-	6.7440 ± 0.0005
(2704) Julian Loewe	5.199 ± 0.291	2.6382	2.6385 ± 0.0001
(3331) Kvistaberg	6.21	-	11.3840 ± 0.0006
(5037) Habing	5.676 ± 0.075	-	2.8290 ± 0.0003
(5235) Jean-Loup	6.709 ± 0.109	-	2.4524 ± 0.0001
(5525) 1991 TS4	5.281 ± 0.104	14.088	14.0740 ± 0.0006
(5754) 1992 FR2	6.337 ± 0.078	8.9021	8.9028 ± 0.0001
(5875) Kuga	7.465 ± 0.144	5.551	5.5512 ± 0.0001
(5952) Davemonet	4.861 ± 0.275	2.6388	4.5132 ± 0.0002
(6819) McGarvey	4.684 ± 0.215	-	2.7217 ± 0.0091
(7558) Yurlov	5.67	4.1121	4.1156 ± 0.0001
(7798) 1996 CL	4.960 ± 0.730	-	3.8724 ± 0.0007
(8645) 1988 TN	5.081 ± 0.329	7.616	7.6251 ± 0.0002
(8761) Crane	4.71	-	2.6386 ± 0.0004
(9531) Jean-Luc	4.176 ± 0.228	-	2.5002 ± 0.0002
(18641) 1998 EG10	3.717 ± 0.650	5.2461	5.2458 ± 0.0001

Table 1: Asteroid synodic periods and amplitudes found within this project compared to literature data gathered previously in LCDB [9] as for Feb. 2019

that the period must clearly be different from the value adopted in the LCDB (Fig. 1). Also, in 8 cases our values for the periods are the first determinations for these targets so far. Figure 2 shows rotational frequencies vs. diameters for V-type asteroids for which these parameters are known. Red symbols denote V-types from our survey.

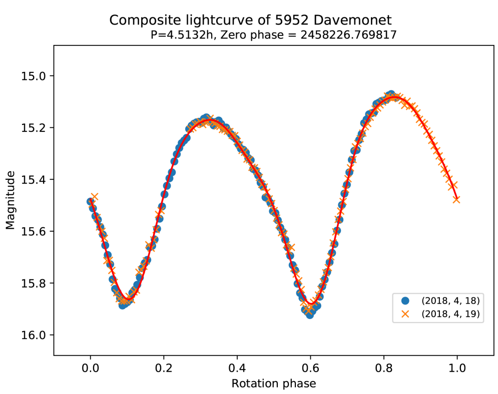

Figure 1: Composite lightcurve of one of our V-type targets, asteroid (5952) Davemonet obtained with the Fourier analysis program described in [4].

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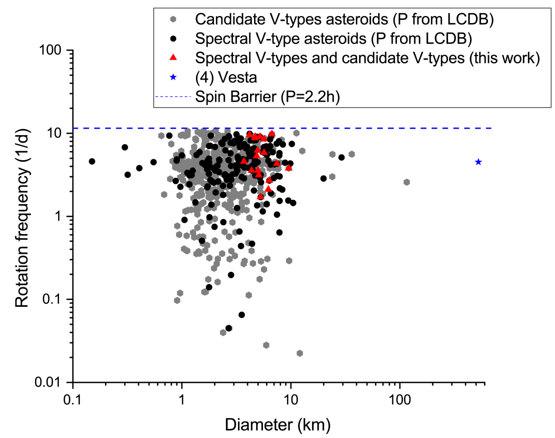

Figure 2: Rotation frequencies (in cycles per day) vs. diameters in km for V-type asteroids. Our targets are marked in red.

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