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Asteroid spin-states of a 4 Gyr-old collisional family.

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Introduction

Asteroid families generated by the collisional fragmentation of a common parent body have been identified using clustering methods of asteroids in their proper orbital element space (Broz & Morbidelli 2013; Tsirvoulis et al. 2018; Dermott et al. 2021). However, there is growing evidence that some of the real families are larger than the corresponding cluster of objects in orbital elements, as well as there are families that escaped identification from clustering methods (Milani et al. 2014). An alternative method has been developed by Bolin et al. (2017); Delbo et al. (2017), in order to identify collisional families from the correlation between the asteroid fragment sizes and their proper semimajor axis distance from the family center (V-shape). This method has been shown to be effective in the cases of the very diffused families that have formed Gyrs ago. Based on this method, a 4 Gyr-old (so-called primordial) collisional family of the inner main belt has been identified consisting of low-albedo asteroids (Delbo et al. 2017). The theory of asteroid family evolution predicts that there is an excess on retrograde asteroids in the inward side of the family's V-shape. For this reason, photometric observations were performed in order to construct their rotational light curves and determine their shape and spin state.

Dataset and Observations

We combined data of asteroid lightcurves that we collected from the databases, sparse photometric data obtained from different surveys and existing shape models. Aiming to enlarge our input dataset used for the shape modelling, which would potentially lead to new and improved shape solutions, we performed additional ground-based photometric observations.

An international observing campaign has been initiated in the framework of our international

initiative called *Ancient Asteroids*[1], aiming to collect dense photometric data for asteroids that belong to the oldest asteroid families (Athanasopoulos et al. 2021).

Method

The photometric datasets include both dense photometric data from ground-based facilities, as well as sparse data from several sky surveys and space missions. Appropriate analysis techniques were used for each type of dataset to extract the asteroid's rotational light curve and use the convex inversion (CI) method developed by Kaasalainen & Torppa (2021); Kaasalainen et al. (2021). So far, the CI has been used to derive asteroid models for more than 3,460 asteroids that are stored in the DAMIT database.

Results

The spin state for 54 family members was determined by additionally using literature and sparse photometric data from ground and space observatories. Moreover, we measured rotation periods for 8 asteroids for the first time.

Combining new and literature data, we determined shapes and spin states for 54 asteroids that belong to the nominal population of the primordial family. This corresponds to 50% of the population in the sliver between the left-wing border of the Polana and the primordial family (see Fig. 1). Specifically, we calculated 23 new complete asteroid models, 16 revised and 8 new partial models, where 32 asteroids have retrograde rotation and 22 prograde.

Based on our analysis, we indicated 9 interlopers in the sample of 54 studied objects. From these 45 confirmed asteroid family members, 29 asteroids (65%) models have retrograde rotation and 16 prograde, including also the partial solutions.

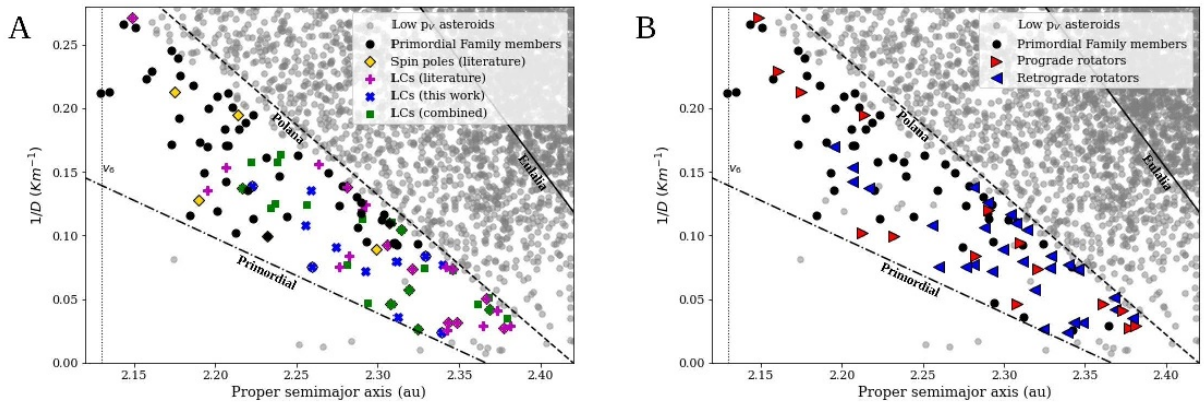

Fig. 1: Panel A: The primordial family members are presented in proper semi-major axis vs. inverse diameter plane, along with the low albedo asteroids. Yellow diamond markers present members with known spin pole from the literature. Moreover, "plus", cross and square markers show the sources of dense lightcurves for these members. Panel B: The left side of the V-shape of the primordial family, where the red markers show the retrograde and blue markers the retrograde asteroids respectively.

Conclusion

We carried out a campaign of photometric observations of those asteroids that have been claimed to be members of one of the oldest collisional (primordial) families in the Solar System and we extract the lightcurves, spin state and shape for 45 members.

The statistical predominance of the retrograde spin poles is due to a physical process, as it was claimed by Delbo et al. 2017, namely formation as collisional fragments of a common parent body, a subsequent dynamical evolution driven by the Yarkovsky effect. The results of this research constitute corroborating evidence that the asteroids as members of a 4 Gry-old collisional family have a common origin, thus strengthening their family membership.

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